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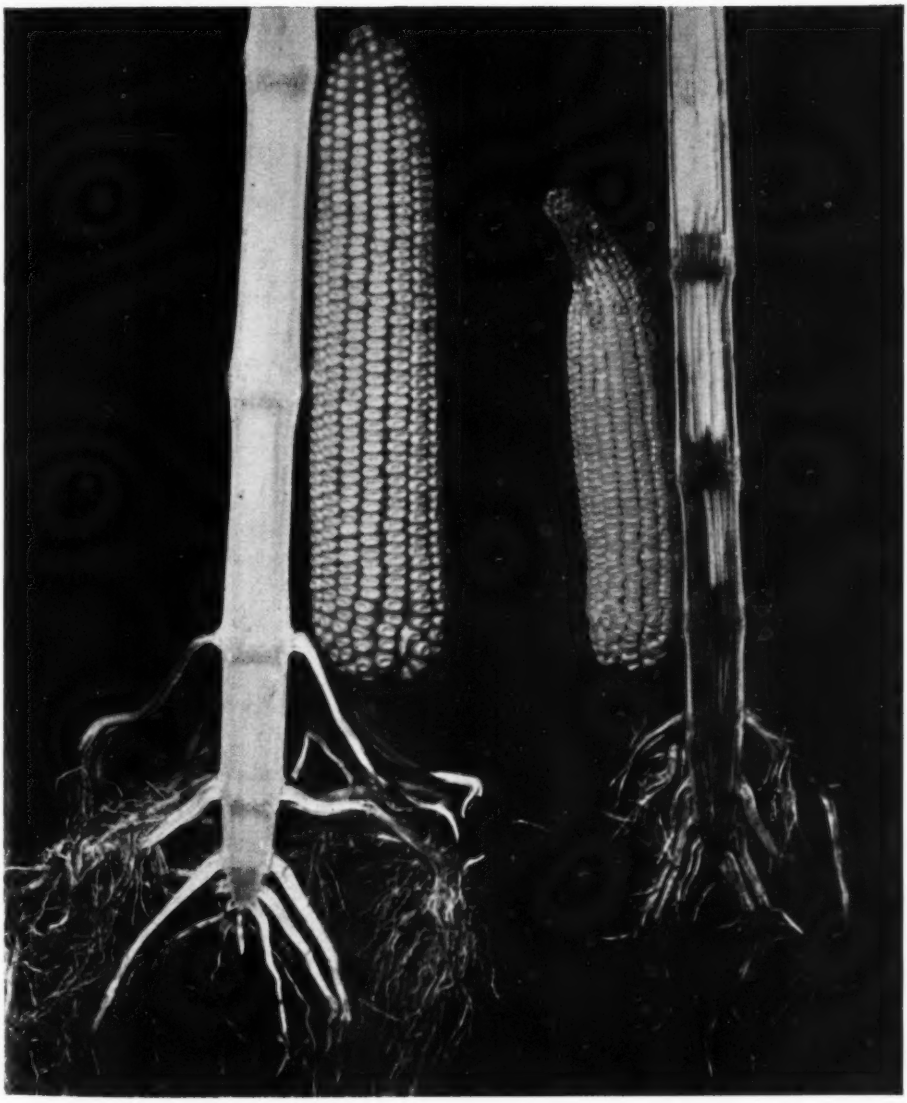

(*Turn to page* 32)

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Editorial Office: 1102 16th Street, N. W., Washington 6, D. C.

VOLUME XXXVI NO. 5

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Apple-blossom Time

Better Crops with PLANT FOOD

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VOL. XXXVI WASHINGTON, D. C., MAY 1952 No. 5

Some Problems . . .

Concerning H_2O

Jeff McDermid

FARMERS, flood controllers, well-dowsers, and conservationists must always keep a weather-eye on the supply and utilization of pure water—defined as H_2O, or the colorless, transparent liquid which falls from the clouds in rain, to form rivers, lakes, and seas, and give crops, livestock, and mankind a chance to survive.

In the average good dictionary you'll first find water set forth in relation to other matter, thus: "At its maximum density, 39.2° F or 4° C, it is the standard for measuring specific gravities, one cubic centimeter weighing one gram." It goes on to say that water freezes at 32° F or 0° C, and boils at 212° F or 100° C. Finally, it is described as the "most important natural solvent, and an important ingredient in the tissues of animals and plants, the human body having about two-thirds of its weight as water."

Some smart alecs addicted to using more potent and flavorous drinking liquids wave away water as something beneath their normal needs. This same foolish disregard of realities has also been observed by other segments of society who rely upon adequate and well-conserved quantities of water for their chosen occupation—such as thoughtless soil-tillers and hydraulic operators of various utilities and gadgets. Of late we have had fresh outbursts of water-witching to locate flowing wells, and cloud seeders whose well-meant efforts to tap the skies must be coupled with sensible soil-conserving practices to make their deluges serve advantageously.

Water, of course, can be had in too great amounts at the wrong place and time. This is a challenge which taxes the best brains, the finest engineering

skill, and the broadest cooperative spirit which our country can produce. Uncontrolled and unwisely used, water is a scourge instead of a blessing. Of late we have come to believe that much good will come from tackling the problem of flood waters through a greater concern and more positive action up beyond the headwaters. Here the little country creeks and the tiny rivulets that run down the sloping fields and often waterlog the tiny upflung spears of corn and wheat are all part of the pattern which points to a real need for that sound philosophy which is now emerging. This theory is simply that what happens to water on some highland area farm may be a link in the terrific pull of gravity which sends mountains of water plunging and gouging to ruin prosperous farms and cities in the helpless valleys below.

TO increase the infiltration rate or the absorbing power of land to retain its alloted supply of heaven-sent water, and to cultivate and till the farm in a manner known to halt those huge and horrid finger scratches of erosion—these are among the most basic of the objectives which now begin to aid us. If well done, they will not only benefit the upland farms where practiced, but the longtime effect (plus other engineering measures) will reduce the awful torrents that tear away men's hopes and lives as winter snows release their moist burden every spring. Instead of dreading those accumulated snows, wise forestry systems and soil-conserving programs in the hands of devoted men will, within a few years, make us rejoice at the bountiful wintertime precipitation. That is, we are moving in now to make ourselves masters of H_2O rather than its cringing victims. Water was put into nature for man's proper use, and certain evidences from ancient times indicate that we are far behind the dawn of history in being able to "live with water" and make it behave.

Erosion control, reduction of sediment deposits in reservoirs, and wiser sanitary regulations to prevent stream pollution by some manufacturing wastes are a few of the larger visions now being made into reality. We must not only have the right amount of water in the right spot at the best time, but the water must be fresh and uncontaminated.

OF course, there will be dry spells and excessive downpours, and semi-arid areas to be irrigated, and swamps to be drained. Nothing ever happens to the ebb and flow of the tides or nature's elements, as people have known for ages. What we are planning to do—as I understand—is to get into step with nature, play along with her powerful laws which we cannot repeal (but maybe amend), and make the best of her vagaries. The land itself is the theater where most of this drama will unfold. Here the chief actors will be our conservation district farmers. They study the water requirements of crops and do contouring, mulching, and terracing to help the plants with short roots to get all the water they need. They also play backstage to thwart the water villain from toting their farms clear down to the Gulf of Mexico—along with several townsites and happy homes.

Scientists call the combined loss of water from the land through plant respiration and soil evaporation a true index of the amount of water from rain or dew that goes from the earth into the air. Lately a paper by L. L. Harrold of the U. S. Soil Conservation Service gives an idea of the sizable amounts of water required for several crops in rotation land, given as maximums also in the season of most water demand. As determined at Coshocton, Ohio, these figures are: Corn at 34 bushels an acre—about 19 inches of water from May through September, or 586 pounds per one pound of corn harvested. Corn at 44 bushels an acre —21.5 inches for the growing period, or 334 pounds of water per pound of

crop. Wheat at 52 bushels an acre—12.4 inches of water used, April-June, or 755 pounds per pound of crop. Meadow grass at 1.5 tons an acre—18.7 inches of water used, or 1,410 pounds of water per pound of crop, from April through August. Meadow grass at about 3 tons an acre—25.9 inches of water used in the same period, or 947 pounds of water per pound of crop.

Mr. Harrold also has some tested figures for an index of the rate by

which corn, wheat, and grassland deplete the available water in their root zones by one inch. He finds that corn exhausts an inch of its available water supply in 5 days during May, 4 days in June, 3 days in July, the same in August, and 11 days in September. Wheat followed by new meadow, he says, depleted its soil moisture by an inch of water in at least 4 days in May, June, and July, and 5 days in August. An alfalfa-brome meadow depleted soil moisture by an inch of water in at least 3 days in May, June, and July, and 4 days in August.

It is explained that these figures would generally apply to the hot, dry, windy, and sunny periods, but under average conditions not so conducive to evaporation and transpiration, the soil moisture would last about 50 per cent longer. It is further evident that differences between localities in solar radiation and air temperatures might alter any such figures considerably. Yet the example is clear, and the measures for retarding water loss in almost any location would be grounded on the same principles.

GROUND water moisture and soil surface moisture are vastly different in relation to crops in a growing season. Only a very few crops, notably alfalfa, have roots of 12 to 20 feet at times which allow them to pierce down and drink up the true ground waters of the deeper strata reservoir. Short root crops drink within close reach. That's the main reason why land management is directed in these days at adding something to the water-holding capacities of the soil close to the plant roots. Only a perfectly bone-dry upper soil layer can be expected to coax any moisture from the deeper ground waters—which does away to some extent with that theory of an easy capillary flow of submoisture up to the soil surface. Thus the best conservationists go in for organic matter and humus and tillage systems. The object is to help the soil replenish its depleted supply of moisture through absorption of much more summer rainfall. It is also possible to put soil in better shape to allow greater penetration of plant roots to the damper layers.

This new revival which links neglected meadows with the gospel of soil and water thrift will culminate this summer in the scientific meetings at Pennsylvania State College in August. Here the most notable research in this field of related study will be brought to light. As explained to me by its sponsors, the International Grasslands Congress will not be a good place for everyday laymen to cogitate. It's a No. 1 assemblage of the scientific boys, and any reports that come from it will have to be shoved through a pretty fine screen. Yet a few of us may pick up some crumbs and pass them on to the ones who must make all these ideals come true—the farmers.

(*Turn to page* 50)

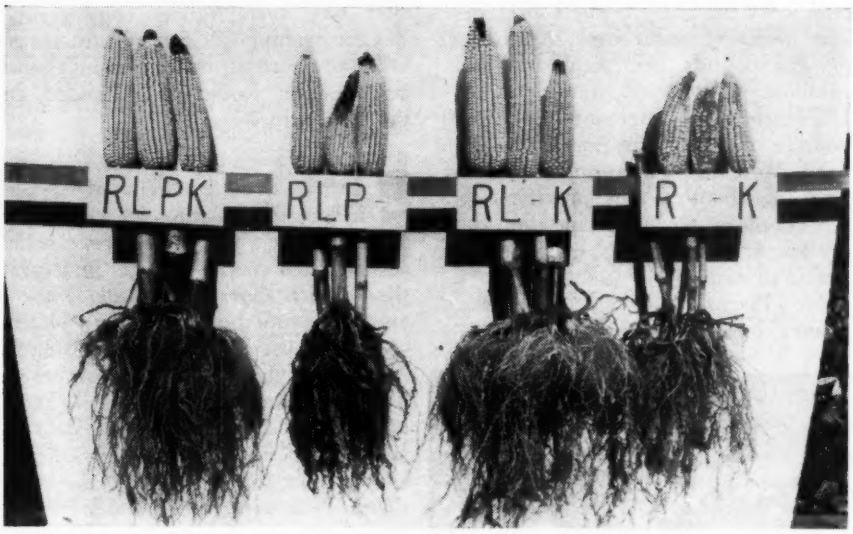

Fig. 1. Potash-starved corn roots rot prematurely. On unlimed plots, root growth is small. Roots starve first. Topgrowth and ears merely reflect root environment, including chemical and physical conditions.

Potassium-nitrogen Balance for High Corn Yields

By P. E. Johnson[1]

Department of Agronomy, University of Illinois, Urbana, Illinois

CORN yields, ear quality, stalk lodging, and disease incidence may be dependent upon the potash-nitrogen balance in the soil. Recent corn fertilization trials on farms on typical gray silt loam soils in southern Illinois confirm soil fertility principles demonstrated year by year at several long-time soil experiment fields. These point the way to higher corn yields by proper use of limestone, phosphates, potash, legumes, and supplementary nitrogen.

Thousands of farmers visit these experiment fields each year, and many wonder if they can repeat on their own farms the basic lessons learned. Corn fertilization trials reported here prove how soil fertility principles can be applied to individual fields. Before studying one-year responses from chemical fertilizers on farms, perhaps we should review long-time indications from some experiment fields on similar soil types.

Illinois Soil Experiment Fields

The Oblong Soil Experiment Field, one of 25 operated by the University of Illinois, is more or less representative of soil conditions in many counties in the southern third of the State.

These gray silt loams on tight clay subsoils might be called multiple de-

[1] The author wishes to express appreciation to Herbert L. Garrard of the American Potash Institute for assistance in conducting demonstrations and supplying certain photographs.

ficiency soils, that is, with several possible limiting factors:

1. At times there may be too much water due to level topography and impervious subsoils.
2. In midseason, too little water may be available for crops because these unimproved, low-organic matter soils have slow water absorption during summer rains, and poor water-holding capacity.
3. Most soils require 3 to 5 tons of limestone before alfalfa and clovers can be grown successfully.
4. Soils are low in native organic matter, so nitrogen release is slow and inadequate.
5. Available phosphorus is low, especially for wheat and legumes.
6. Available potassium becomes inadequate rapidly, especially for legume hays, corn, and soybeans.

The Oblong Field, started in 1912, has been operated for 40 years, over 10 rotations, with various combinations of treatments of limestone, phosphates, potash, manure, crop residues, and supplementary nitrogen. (See Table I and Fig. 3 for yield data.)

Soon after treatments were started, the greatest response was to limestone, especially on the stand and growth of legumes. By the end of the third rotation, around 1925, corn yields on the limed plots without additional phosphates and potash were becoming less and less satisfactory. Reserves of these nutrients were becoming depleted. Young corn plants on limed plots began showing yellow-edged leaves, typical of potash starvation. Some purplish leaves were noted, indicative of low available phosphorus. But when phosphorus was applied on the adjoining limed plot, it merely increased the potash needs.

In 1951, as in recent years, corn plants showed yellow-edged leaf symptoms almost from time of emergence on the lime alone or lime-phosphate plots. The potash-hungry leaves develop brown marginal "scorch" later, especially as the ear appears and begins to fill.

Fig. 2. Corn stalks lodge more on low-potash plots, year after year, especially where extra nitrogen is applied—left foreground. Oblong Soil Experiment Field, October 25, 1950.

Such potash-starved stalks sometimes are root-lodged by midseason due to poor root growth. More leaning, broken, and down stalks usually appear in potash-starved fields late in the season because of premature rotting of roots and lower portions of stalks. (See Figs. 1 and 2.) Chaffy, poor quality ears will be on such stalks.

In 1951 most stalks on the limestone-phosphate plot at Oblong Field were leaning or down. Sidedressing of 60 lbs. of nitrogen across this low-potash plot (RLP) increased the lodging to about 100 per cent by harvest time. Since these plots are harvested by hand, every ear is picked regardless of size. With mechanical pickers less corn would be recovered from low-potash areas because of lodged and broken stalks. Adjoining halves of the RL and RLP plots which received potash with nitrogen produced 100-bushel corn with no brown marginal leaf areas and practically no lodging even when extra nitrogen was sidedressed.

Fig. 3 illustrates corn yield trends with certain basic and supplementary treatments at the Oblong Field. Yields of 100 bushels have been maintained for the last four years by the long-time use of limestone, rock phosphate, and potash (RLPK plot). Where potash was applied to the once potash-deficient halves of the RL and RLP plots, corn yields went to 90 and 98 bushels. Extra nitrogen boosted these to 99 and 103 bushels. When nitrogen and potash were added, on the RLPK plot, the top yield was 113 bushels. These average yields seem high, but many farmers in this soil area are now producing as high or higher yields than cited here.

TABLE I.—FOUR-YEAR AVERAGE CORN YIELDS (1948-51), OBLONG SOIL EXPERIMENT FIELD, WITH ADDITIONAL INCREASES FROM EXTRA NITROGEN AND POTASH. ALSO MIXED HAY YIELDS, WITH AND WITHOUT EXTRA POTASH.

Basic treatments [1]	Corn yields on basic treatments Bu.	Increases in corn yields—Bu. per acre					Mixed hay yields on basic treatments	Mixed hay yields with extra 50# K_2O	Incr. hay yields from extra potash
		From both N+K	From 60 lbs. N		From 50 lbs. K_2O				
			N alone	NK/K	K alone	NK/N			
							Tons	*Tons*	*Tons*
1—O	23	27	9	14	13	18	.56	.48	−.08
2—M	54	18	7	13	3	11	.78	.83	.05
3—ML	93 [2]	9	4	0	9	5	1.80*	2.14*	.34*
4—MLP	97 [2]	15	2	11	4	13	2.11*	2.45*	.34*
5–O	31	18	5	15	3	13	.39	.35	−.04
6—R	37	16	3	2	14	13	.59	.63	.04
7—RL	64	35	−2	9	26	37	1.32	1.68	.36*
8—RLP	71	32	2	5	27	30	1.92	2.32*	.40*
9—RLPK	101	12	3	14	−2	9	2.34*	2.23*	−.11*
10—O	33	11	4	12	−1	7	.41	.40	−.01

[1] Key to basic treatments:
O—No treatment, no residues
M—1 lb. manure for each lb. dry matter removed, applied on corn
R—Wheat straw, soybean residues, and corn stalks residual
L—Limestone, 4 T. 1912; 2 T. 1922; 2 T. 1938
P—4 T. rock phosphate applied in period 1912-1924. None since
K—50 lbs. K_2O per A. per year average. 50 lbs. K_2O on corn, 100 lbs. on wheat, 50 lbs. on clover stubble
Extra K—50 lbs. K_2O, same as above
N—60 lbs. N sidedressed.

[2] Moles often reduce stands on manured plots.

* Legumes predominate.

Corn yields on long-time experimental plots reflect effects of certain soil treatments on growth of previous hay crops. (See Table I.) In other words, the nitrogen in the soil available for corn depends largely on the success or failure of legumes in the cropping system.

Total yields of hay alone do not tell a true story of value where a forage mixture of alfalfa, red clover, alsike, and timothy is seeded uniformly across all plots. Mostly, stunted timothy and weeds survive on the untreated plots. Without limestone, little or no clover lives through the winter. Alfalfa and clovers tend to predominate and crowd out timothy on plots with adequate limestone, phosphates, and potash. (See Fig. 4.) Limed plots without potash have a thinner stand and shorter growth of alfalfa and clovers, with relatively more timothy. Timothy survives and grows fairly well at a lower potash level than alfalfa or clovers. Extra potash fertilizer even increases predominance of legumes on manured plots. This might be termed the battle of the species, and we see it year after year on the long-time fertility plots.

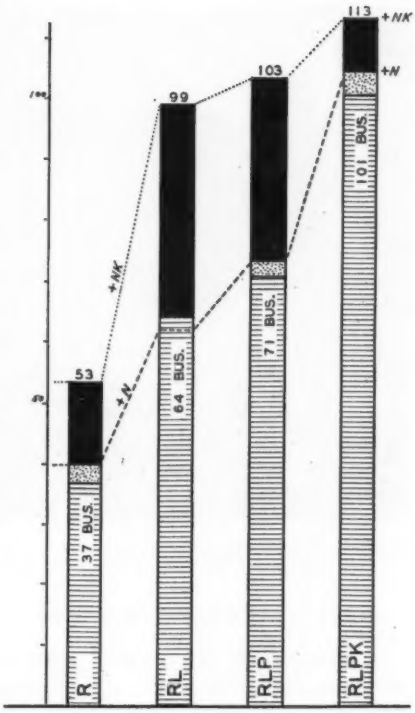

Fig. 3. Four-year average corn yields from basic treatments and with extra nitrogen and potash. For data see plots 6 to 9, in Table I. Oblong Soil Experiment Field.

Physical Conditions Changed Too

As limestone and fertilizers change the chemical composition of the soil, physical conditions change too, partly because of type of crops resulting. Limed plots often can be plowed in the spring 7 to 10 days before unlimed plots.

Soil Tests Guide Treatments

Thus far effects of long-continued soil management practices have been discussed. Now let us consider some one-year responses from fertilizers on individual farms.

Soil tests which are used widely in Illinois to guide soil treatment recommendations are calibrated largely from the long-time experiments.

There are dozens of soil types, and also many man-made variations within each soil type. For instance, on each experimental field several man-made differences in fertility levels or balances have been created, side by side, all on the same soil type. It is not difficult to locate farmers' fields which are typical of every plot in the experiment fields. Present needs within a soil type depend so much on what has or has not been done before. Some soils have been limed and relimed with little thought as to needed nitrogen, phosphate, or potash. Too many have grown mostly corn and soybeans, with too few soil-improving legume crops for several rotations. Under such variable conditions, farm advisers or county agents often are asked to make blanket fertilizer recommendations for corn, with or without soil tests. By using soil tests, one can estimate current chemical needs in spite of variable past practices.

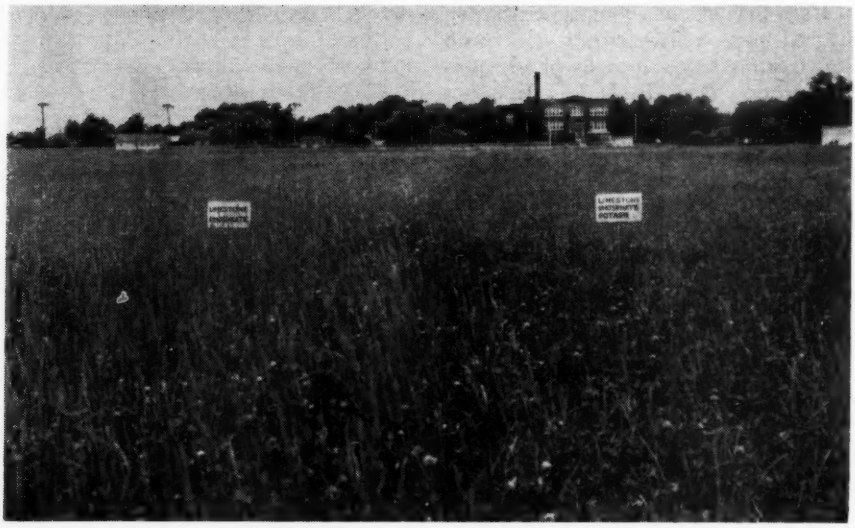

Fig. 4. Clovers and alfalfa predominate with adequate potash, right; but timothy crowds out legumes at low-potash levels, left. Oblong Soil Experiment Field, June 12, 1950.

Farmer's Practical Questions

A farmer who bothers to obtain soil tests on his soils often asks these questions:

1. What fertilizers shall I use on corn this year, and what results may I expect on yields and quality?
2. Will a proper potash-nitrogen balance reduce leaning and broken stalks?
3. Will clovers still do the job in supplying nitrogen for high corn yields? Can extra nitrogen treatments be used profitably?
4. Does method of handling clover hay crops really affect the amounts of nitrogen available for corn crops to follow?

Selecting Demonstration Fields

In order to answer some of these questions, demonstration fields were selected according to soil test indications and cropping histories. Corn in 1951 trials followed red clover or sweet clover. Poor clover on some fields was not due to lack of limestone, but probably caused by low available phosphorus and/or potassium. Some 1950 trials were corn following corn. Soil tests on these farms correlated somewhat with those from the lime-phosphate plot of the Oblong Field. (See Table II.)

Demonstration Layouts

Several grades of fertilizers were used (3-9-27 or 0-9-27, 3-9-18, 10-10-10, 3-12-12, 2-12-6, and 4-16-0 in some cases) at 200 pounds per acre drilled in the row at planting time. Crosswise of the rows 60% muriate of potash had been broadcast at rates of 200 to 375 pounds per acre with a low-down spreader over plowed ground and then disced in. These 200-ft. strips of extra potash were to test the adequacy of the potash supplied from different fertilizer grades in the row applications.

Then at the time of the last cultivation, extra nitrogen (60 lbs. N per acre) was sidedressed on one-half of each of the above treatments or combinations. Thus each fertilizer stood alone, with extra nitrogen, with extra potash, and with both extra N and K.

Farm Advisers R. E. Apple of Jasper County, Clinton Cutright of Effingham County, Darrell Fike of Crawford

Fig. 5. Leaf breakdown was very severe by September 12 with nitrogen alone, left; but most leaves were still functioning with nitrogen and potash, right. George Deatherage Farm, Oblong, Ill., 1951.

County, a number of fertilizer dealers, G. I. instructors, and farmers assisted in planting and harvesting these corn test plots.

Early Growth Improved

Improved early growth differences, due to row fertilization, showed up on most farms soon after emergence. Under very low potash conditions such as at Deatherage and Mette plots, corn on unfertilized plots or with 4-16-0 developed yellow-edged leaves with dead tips before plants were 6 inches high.

In June, corn on most row-fertilized plots or with 0-0-60 broadcast looked very well with the higher nitrogen starters, as 10-10-10, producing darker green plants. The 2-12-6 plots, with only 12 lbs. K_2O per acre, showed no potash deficiency symptoms at this time. Of course, unfertilized rows were quite stunted.

In the past, nitrogen and phosphorus in mixed fertilizers have been given the most credit for the early starter effects. Too little has been said about the early growth or "starter" effects

TABLE II.—SOIL TEST RECORDS AND COMPARISONS.

Location	Soil type	Limestone required Tons/A	Available phosphorus	Available potassium Lbs. K/A
1951				
Oblong S. E. F., RLP plot	Cisne	0	High	70–90
Geo. Deatherage, Oblong, Ill.	Cisne	0	Med. –*	40
Roman Mette, Dieterich	Cisne	1	Low –	70
Stanley Adams, Teutopolis	Cisne	0	Low –	70–80
Paul Yaw, Newton	Rinard	0	Med. –*	70–80
1950				
Stanley Adams, Teutopolis	Cisne	0	Low	40–90
Jesse Boggs, Hidalgo	Cisne	0	Low	40

* Rock phosphate applied recently.

of potash on these soils. Broadcast potash which crossed unfertilized rows gave similar early growth stimulation and even improved the June growth on low-potash fields.

Potash deficiency symptoms usually are noticed first on corn in dead furrows or in areas where tight subsoils are closest to the surface. The top-soil feeding area is shallower. Similar deficiency symptoms will spread gradually over the field as the potash is depleted.

Farmers often ask whether young corn plants showing potash starvation symptoms can be sidedressed successfully with muriate of potash. Sidedressing potash on stunted corn will never be as effective as application of the same amount of potash in the row at planting. Sidedressing of potash might be used either as an emergency measure, or to supplement row applications.

Some fertilized plots, which showed excellent growth from starter fertilizers in June, broke down in August as ear development began to make greater demands for nitrogen and potash.

For instance, in the 1951 Adams field where corn followed a poor stand of clover with all hay removed, extreme nitrogen deficiency symptoms appeared in August on plots with fertilizers alone or potash broadcast. These nitrogen starvation symptoms on lower leaves, with yellowish tips and yellowing extending up the midrib in a V-shape, are sometimes erroneously called "dry weather firing." When mineral nitrogen supplemented clover nitrogen this type of firing did not occur.

Corn Leaf Breakdown

By early September extensive leaf deterioration due to insufficient potassium was seen in several low-potash fields on the Mette and Deatherage farms. Leaf edges were almost all brown on unfertilized rows.

Some of the row-drilled fertilizers which seemed to be excellent starters were inadequate by September because of too little potash. The leaf breakdown seemed inversely proportional to the potash supplied by the fertilizer combination. The 2-12-6, which looked good as a starter in June, fell far short of supplying enough potash to finish a 100-bushel corn crop. The 3-12-12 and 10-10-10 rows looked better than the 2-12-6, but most leaf edges were brown. With 200 pounds of 3-9-27 or 0-9-27, leaves were in the best condition of all row-applied fertilizers. Leaves were in excellent condition in early September where extra heavy potash applications had been broadcast.

Leaf Blight Noted

In addition to the physiological breakdown of leaves, necrotic spots due to northern leaf blight (*Helminthosporium turcicum*) were seen on the Deatherage plots, on the Kaley Tucker plots near Newton, and at the Toledo Soil Experiment field.

Between September 4 and September 12, when the Deatherage plots were inspected and photographed, leaf breakdown had progressed rapidly. (See Fig. 5.) Leaves were mostly all dead on the potash-starved rows, and the condition was worst where extra nitrogen had been sidedressed. With adequate potash, many leaves were still green and ears were ripening on fairly green stalks.

It seemed that the oval blotches caused by the leaf blight were less extensive on the high-potash plots. It is not certain whether the extra potash merely prevented physiological breakdown of the leaf tissues due to potassium deficiency, or that the extra potash actually retarded the damage from the leaf blight disease or diseases within the stalk or roots.

More Healthy Root Growth

Examinations of corn roots near harvest time have shown big variations in both total root growth and also condition of those roots. Figure 1 illus-

(*Turn to page* 47)

Why Plants Differ in Fertilizer Needs and Mineral Composition*

By Mack Drake, W. G. Colby and Jonas Vengris

Massachusetts Agricultural Experiment Station, Amherst, Massachusetts

WHY do different crop plants vary greatly in mineral composition even though they are grown in the same soil at the same time under the same conditions? Why are many leguminous plants such as alfalfa and red clover much more sensitive to low levels of available soil potassium than are such grasses as timothy, Kentucky bluegrass, and red top? Can we also explain why certain grasses, smooth brome for example, make much more compatible mixtures with ladino clover than Kentucky bluegrass or bent grass?

Is there a fundamental explanation for recommending large amounts of potash fertilizers for potatoes, tomatoes, and tobacco? How serious are weeds as competitors with crop plants for minerals?

The results of recent fundamental research provide sound and logical answers to the above questions as well as other questions relating to the growth and culture of crop plants.

Need for Fundamental Research. Research work is like unraveling the stitching on a feed or fertilizer bag in dim light or with gloved hands. One fumbles about, trying first one end and then the other to locate the key thread. After exercising much patience and perseverance, this key thread is discovered and then the process of opening proceeds easily and rapidly. Similarly in research, one works on a problem from one approach and then another, seemingly with little success. Suddenly the discovery or application of a fundamental truth or key principle offers a solution to the problem under investigation and provides leads on other related problems.

The authors' original objective was to find satisfactory answers to some of the puzzling problems in fertilization and management of forage crops in Massachusetts. Why do plants differ in ability to obtain calcium, magnesium, cobalt, and potassium from the soil and why is it so difficult to maintain stands of legumes when grown in association with grasses in hay fields and pastures? The key which provided the answers involved two principles: (1) Plant roots have base or cation exchange capacities and (2) these cation exchange values differ greatly for different plant species.

Importance of base or cation exchange in soils. For many years the importance of base exchange capacity as related to soil fertility has been recognized. "Base or cation exchange capacity" of a soil refers to the chemical power or ability of that soil to absorb or "soak up" and hold the bases or cations, such as potassium, calcium, magnesium, sodium, manganese, and cobalt. Materials with tremendous surface area per unit weight, such as clay, sponges, or microscopic sandwiches, are known as colloids and are responsible

* See "Cation Exchange Capacity of Plant Roots," 1951, Soil Sci. 72:139-147.

for the base or cation exchange properties. In the soil these colloid materials are made up of (a) inorganic-clay minerals and (b) organic-humus, which is composed of resistant residues and products of the breaking-down or rotting of plant life by soil organisms. Adequate base exchange capacity in a soil is highly desirable, as the above bases mentioned are absorbed and are retained against loss by leaching. At the same time these absorbed bases are available and may be taken up by growing plants.

Plant roots also have cation exchange. The fact that plant roots have cation exchange properties was reported in 1916 by Devaux, a French chemist. Colloidal substances, such as pectin, of the root and root hair surface provide this cation exchange property; however, this important fact has not been widely publicized or used effectively in seeking an understanding of how plants feed on soil minerals. Recently the Swedish scientists, Dr. Sante Mattson [1] and Dr. Lambert Wiklander, and co-workers developed a way to measure relative cation exchange capacity of plant roots. Using their technique, it has been possible to show that roots of many different plant species differ greatly in cation exchange capacity (Table I); for example, the cation exchange capacity of the roots of the legumes are approximately double the values for the grasses. Furthermore, there are important differences in the cation exchange capacities of our common forage grasses. Smooth brome, alta, or tall fescue, and orchard grass have high cation exchange values whereas red top and the bent grasses have low cation exchange values.

Colloids of the plant root and soil compete for bases or cations. Plants obtain such cations as calcium, magnesium, cobalt, and potassium from the soil solution and from the soil colloids (contact exchange). The cation competition between the plant root colloids and the soil colloids becomes more critical as the supply of cations in the soil solution is reduced. On many soils the cation content of the soil solution is greatly reduced during the growing season because of high uptake and removal by rapidly growing crops.

Principle of adsorption of divalent and monovalent cations. High cation exchange colloids adsorb or attract and hold such divalent cations as calcium, magnesium, and cobalt with much greater energy or force than the monovalent cation potassium. Conversely, colloids with low cation exchange capacity attract and hold the monovalent cation potassium with much greater force than calcium and magnesium. This fundamental principle, Donnan distribution of cations, holds for colloids of plant roots as well as for soil colloids (Mattson). For example, the high cation exchange soil colloids, montmorillonite and beidellite hold calcium and magnesium with much greater energy than potassium. However, potassium is held with greater energy by the low cation exchange soil colloid kaolinite. Similarly, the low cation exchange roots of red top and bent grass adsorb potassium with much greater energy than calcium and magnesium.

Since high cation exchange roots, such as alfalfa, the clovers, and many other dicots, adsorb calcium and magnesium with much greater energy than potassium, large amounts of the adsorbed calcium and magnesium enter the root cell, and thereby to a degree potassium is excluded. Thus a natural physical-chemical barrier restricts the entry of potassium into those plant roots of high cation exchange. Moderate to high amounts of potassium in the soil solution will overcome this barrier and will force potassium into the high cation exchange roots. Research and field experience prove that a relatively high level of available potas-

[1] Dr. Mattson was for many years associated with the U. S. Department of Agriculture and with the New Jersey Agricultural Experiment Station. He is widely known for his many fundamental contributions in the field of soil science.

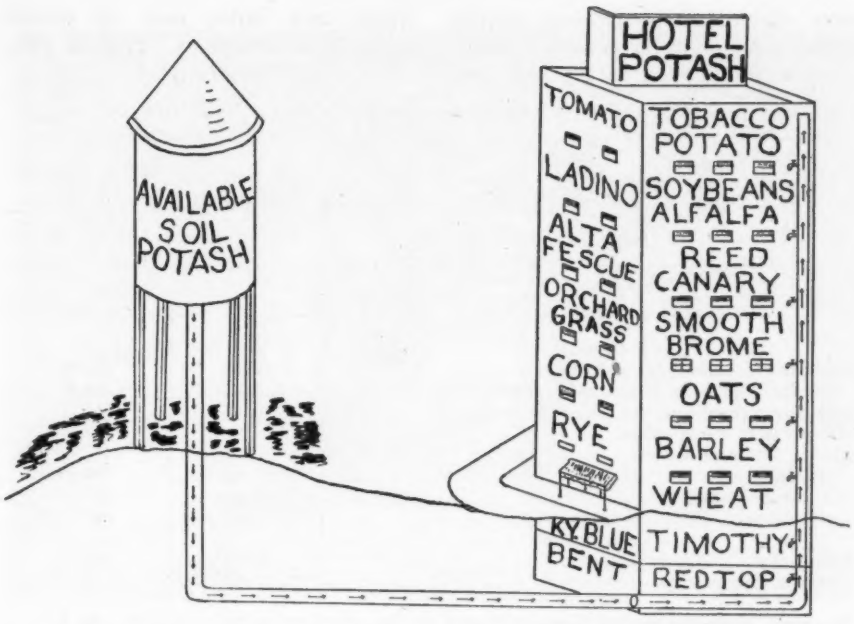

Fig. 1. Plants differ greatly in ability to utilize soil potassium. While the crop "tenants" in the sub-basement of "Hotel Potash" can obtain enough potassium from soils very low in available potassium, increasingly higher levels are required for the "tenants" of the upper floors.

sium either from the soil or the fertilizer bag is necessary for high yield and longevity of legume stands.

In sharp contrast, the low cation exchange roots of timothy, red top, and bent grass adsorb potassium with much greater energy than calcium or magnesium. Thus at low levels of available soil potassium, plants with low cation exchange roots are able to obtain potassium in amounts sufficient for growth, whereas plants with high cation exchange roots cannot.

Just as the natural law of gravity forces water to run downhill, natural laws of colloid chemistry (Donnan equilibrium) (1) force the roots of legumes and many other dicot plants to take up larger amounts of calcium and magnesium than potassium and (2) force grasses and many other monocots to take up larger amounts of potassium than calcium and magnesium.

Effect of increasing soil solution potassium—Table II. At low levels of available soil potassium, one would expect the oat plant with high root exchange capacity to take up relatively more calcium and magnesium and less potassium, and the wheat plant with low cation exchange roots to take up less calcium and magnesium and relatively more potassium. On a soil low in available potassium, the wheat plants contained 155 per cent; barley, 90 per cent; and oats, 55 per cent of available potassium (exchangeable plus soil solution Table II). The uptake of potassium by these three cereals with similar physical growth characteristics was in complete agreement with the cation exchange capacities of their roots (Table I). As expected, oat roots (22.8) adsorbed the least, barley (12.3) an intermediate, and wheat (9.0) the greatest amount of potassium. The relationship of cation exchange capacity of the plant root and the potassium vs. calcium and magnesium adsorption differential holds only on soils with low to moderate amounts of available or exchangeable potassium (low levels of

ionic concentrations—Donnan equilibrium). As larger increments of potassium were supplied to the soil, oats, wheat, and barley took up similar amounts of potassium. Highest rates

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TABLE I.—CATION-EXCHANGE CAPACITY OF PLANT ROOTS

Plant	Ultimate pH	Cation exchange capacity
		me/100 gm.*
Dicotyledons		
Legumes		
Soybeans (Lincoln), *Glycine soja*	3.26	58.9
Canadian field peas, *Pisum sativum arvense*	3.35	49.6
Red clover (medium), *Trifolium pratense*	3.37	47.5
Hairy vetch, *Vicia villosa*	3.41	44.1
Alfalfa *Medicago sativa*		
Atlantic	3.42	48.0
Kansas common	3.49	40.0
Ladino clover, *Trifolium repens* var	3.43	43.4
Vegetables		
Irish potato, *Solanum tuberosum*	3.62	38.1
Tomato, *Lycopersicum esculentum*	3.67	34.6
Weeds		
Ragweed, *Ambrosia artemisiifolia*	3.27	58.9
Pigweed, *Amaranthus retroflexus*	3.35	42.3
Smartweed, *Polygonum pensylvanicum*	3.48	41.1
Purslane, *Portulaca oleracea*	3.53	40.7
Lamb's-quarters, *Chemopodium album*	3.94	25.0
Monocotyledons		
Grasses		
Reed canary, *Phalaris arundinacea*	3.80	30.8
Alta fescue, *Festuca elatier arundinacea*	3.60	30.4
Orchard grass, *Dactylis glomerata*		
Colby	3.68	25.6
Commercial	3.72	24.9
Smooth brome, *Bromus inermis*		
Southern	3.65	24.8
Northern	3.72	24.4
Canadian bluegrass, *Poa compressa*	3.78	24.1
Timothy, *Phleum pratense*	3.78	22.6
Tall meadow oat grass, *Arrhenatherum elatius*	3.67	22.5
Kentucky bluegrass, *Poa pratensis*	3.83	21.6
Redtop, *Agrostis alba*	3.92	17.3
Rhode Island or Colonial bentgrass, *Agrostis tenuis*	3.95	16.3
Cereals		
Corn (Yellow Dent), *Zea Mays indentata*	3.68	26.0
Sweet corn (Golden Cross), *Zea Mays saccharata*	3.80	22.2
Spring oats, *Avena sativa*	3.78	22.8
Rosen rye, *Secale cereale*	4.12	15.1
Barley, *Hordeum vulgare*	4.25	12.3
Winter wheat, *Triticum vulgare*	4.70	9.0
Weeds		
Nutgrass, *Cyperus esculentus*	3.51	28.7
Quackgrass, *Agropyron repens*	3.78	19.8
Foxtail, *Setaria glauca*	4.65	11.4

* Oven-dry weight.

Fig. 1. J. Maurice Smith and his prize-winning 17 bales of cotton.

Five-acre Cotton King

By H. G. Boylston

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J. MAURICE Smith, cotton farmer living near Johnston in Edgefield County, South Carolina established a new record in cotton production on five acres in 1951. As a member of the State Five-acre Cotton Contest, and carrying out the practices that have been tried and proven, he produced 8,380 pounds of lint cotton of staple length 1 1/16 inches. He received $750 for placing first in South Carolina and a $1,500 sweepstakes prize from the Atlantic Cotton Association for beating all previous records.

This contest, started in 1926, has had more than 13,000 five-acre fields entered in the past 25 years. From it, the farmers have learned which are the best practices for maximum yields of quality cotton.

The farm on which Mr. Smith made his record yield is generally of the Marlboro type of soil. The field used for cotton in 1951 is of good quality Marlboro. In 1950, it had grown small grains and soybeans. Seeds were harvested from both crops with a combine. Mr. Smith reports that he prepared the soil by disking it several times.

Prior to planting, 1,000 pounds per acre of 3-9-9 fertilizer were broadcast. Just before planting, he applied 500 pounds per acre of 3-9-9 in the drill. The rows were 30 inches apart, and on April 6 he planted Coker 100 Wilt Resistant at the rate of two bushels per acre. A good stand was obtained and 2-5 stalks were left in hills about 8 inches apart.

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Terrebonne Clay Loam Responds to More Potassium in the Fertilizer*

By Lawrence J. O'Grady

Soil Science Department, OKA Institute, La Trappe, Quebec

MOST of the heavier soils in the Province of Quebec are well supplied with total potassium. This is particularly true of the clays and clay loams that have originated from the receding waters of the Champlain Sea and that are found at altitudes not exceeding 150 feet above sea level. Such soils generally contain no less than 2% total potash (K_2O) and may often contain as much as 3%.

Despite this high total potassium content, some of these soils, when receiving larger fertilizer applications, have been noticed to bear plants exhibiting slight potassium deficiencies. The fertilizers applied were those generally recommended for such soils, i.e., fertilizers containing a minimum percentage of potash (2-12-6, 2-16-6, 4-12-6) as compared to those recommended for lighter soils. It was, therefore, presumed that these soils did not receive an adequate amount of potassium to meet the growing plant's requirements. In order to investigate the possibility of potassium being a limiting factor, the following experiments were conducted to substantiate the observations, and field plots were set up in 1950 and 1951 for such crops as hay, oats, sweet peppers, tomatoes, and onions.

The soil used in these experiments is classified as a Terrebonne clay loam with the following characteristics: Well-drained (open drains), flat topography, fair to good structure. It has a good water-holding capacity (moisture equivalent, 28%), a fair total organic matter content (5.1%), and is practically neutral in reaction (pH 7.2). Its cation exchange capacity is high (24 m.e. per 100 gms.), and the per cent base saturation was 84%. The total K_2O content was found to be 2.07% or 41,400 lbs./acre of which 0.329 m.e. per 100 gms. or 257.5 lbs./acre were in the exchangeable form. This exchangeable K_2O represents 1.37% of the exchange capacity. No manure was applied to the plots. In 1950, rainfall and temperature were satisfactory, while in 1951 rainfall was excessive and temperatures were below average.

The Treatments

For each of the five crops mentioned (hay, oats, sweet peppers, tomatoes, and onions), five different plots were measured out and treated with increasing amounts of potassium in the fertilizer. For all crops, the checks consisted of applications of 4-12-6 in amounts varying with the crops. The fertilizers were broadcast either at the time of planting or in early May on the 3-year-old meadow.

Hay Plots

Table I summarizes the treatment and the yields for the hay plots on a 3-year-old meadow. These plots measured 244 by 54 feet or 0.3025 acre. Acre yields were computed from three

* Work sponsored by E. K. Hampson, Manager for Canada, American Potash Institute, to whom the writer wishes to express his thanks for the much appreciated collaboration and financial aid.

areas 20 by 20 feet selected in each plot.

TABLE I.—EFFECT OF INCREASING AMOUNTS OF POTASSIUM IN THE FERTILIZER ON YIELDS OF HAY

Plot No.	Fertilizer treatment		Yields (dry hay)	
	Formula	Amount lbs./ acre	1950 tons/ acre	1951 tons/ acre
1 (check)	4–12–6	500	1.71	2.44
2	4–12–8	500	1.82	2.49
3	4–12–10	500	2.21	2.77
4	4–12–12	500	2.58	3.07
5	4–12–6	700	2.65	2.95

The hay consisted of timothy and red and alsike clover on a 3-year-old meadow. In comparison with the check (500 lbs. of 4-12-6 per acre), the highest yields were obtained on Plots 4 and 5 (500 lbs. of 4-12-12 and 700 lbs. of 4-12-6 per acre, respectively). The yields increased with an increase of the potassium in the fertilizers It will be noted that 500 lbs. of 4-12-12 per acre gave just as good results as 700 lbs. of 4-12-6.

In the check plot (500 lbs. of 4-12-6 per acre) very few vetch plants volunteered. As the potassium content of the fertilizers increased, more vetch appeared. Plots 4 and 5, which were quite similar in appearance at harvest, produced the greatest amounts of vetch.

Oat Plots

The oat plots measured 244 by 54 feet or 0.3025 acre. Yields per acre were calculated from the threshings on the entire plot. Table II affords a resume of the various treatments and yields of grain. No oat plots were set up in 1950.

Fertilizers were applied broadcast on May 2, and the oats (Cartier variety) were seeded down the same day at the rate of four bushels per acre. Harvest took place on August 8. The oats grew fast and tall and the grain was of high quality. No lodging occurred in spite of strong winds and heavy rains, except in Plot 5 where a negligible area of lodging (1 sq. yd.) was detected.

TABLE II.—EFFECT OF INCREASING AMOUNTS OF POTASSIUM IN THE FERTILIZER ON YIELDS OF OATS

Plot No.	Fertilizer treatment		Yields (year 1951) bu./acre
	Formula	Amount lbs./acre	
1 (check)	4–12–6	500	51.2
2	4–12–8	500	50.4
3	4–12–10	500	55.7
4	4–12–12	500	61.3
5	4–12–6	700	59.8

Sweet Pepper Plots

The sweet pepper plots measured 70 by 60 feet or 0.0964 acre. The yields per acre were calculated from each entire plot. Table III condenses the data on treatments and yields.

TABLE III.—EFFECT OF INCREASING AMOUNTS OF POTASSIUM IN THE FERTILIZER ON YIELDS OF SWEET PEPPERS

Plot No.	Fertilizer treatment		Yields	
	Formula	Amount lbs./ acre	1950 bu./ acre	1951 bu./ acre
1 (check)	4–12–6	1,200	185.8	177.3
2	4–12–8	1,200	191.5	179.1
3	4–12–10	1,200	237.4	207.8
4	4–12–12	1,200	214.3	212.4
5	4–12–6	1,600	232.8	206.2

The sweet peppers (California) were put down with the transplanter. No starter solution was used and the plants were set at distances of 2 feet on the row and 2½ feet between the rows.

Tomato Plots

The size of these tomato plots was 66 by 48 feet or 0.0727 acre. The yields from each plot were converted into

yields per acre. Asgrow tomatoes were transplanted on May 25 and set at distances of 3 by 3 feet. No starter solution was used. Table IV summarizes the data.

TABLE IV.—EFFECT OF INCREASING AMOUNTS OF POTASSIUM IN THE FERTILIZER ON YIELDS OF TOMATOES

Plot No.	Fertilizer treatment		Yields (year 1950) tons/acre
	Formula	Amount lbs./acre	
1 (check)	4–12–6	1,000	11.56
2	4–12–8	1,000	12.54
3	4–12–10	1,000	14.09
4	4–12–12	1,000	13.67
5	4–12–6	1,500	13.82

In 1951 these plots were of no experimental value. The continuous wet and cold weather prevented normal fructification and favored the expansion of the snail population which ruined an important portion of the crop in the green stage. DDT and lead arsenate mixtures applied as sprays had no effect. The plants were vigorous and healthy in appearance but yields were not recorded.

Onion Plots

Each of the five onion plots measured 42 by 54 feet or 0.0521 acre. The yields from each plot were weighed and converted into acre yields. Table V indicates the various soil treatments along with the corresponding yields.

The Sweet Spanish onions were transplanted 6 inches apart on the row with a 12-inch spacing between the rows. From the figures in Table V, the best yields were obtained on Plot 3 in 1950 and on Plot 4 in 1951, with respective applications of 1,500 lbs. of 4-12-10 and 1,500 lbs. of 4-12-12. It has not been clearly explained why in 1950, Plot 5 (2,000 lbs. of 4-12-6 per acre) gave lower results than Plot 1 (1,500 lbs. of 4-12-6 per acre). Analytical data afford no satisfactory explanation. It is presumed that moisture and structure may have played a part in reducing the yields, since Plot 5 was located at the end of the field where the tractor had frequently turned about when working the land in 1950. One important feature of Plot 4 is the earlier maturing of the plants which dried away to fall approximately 10 days sooner than those on other plots (Fig. 1). The additional amount of potassium (4-12-12) seems to have hastened maturity and enabled the plant to complete its growth cycle sooner, in no way affecting quality or reducing yields.

TABLE V.—EFFECT OF INCREASING AMOUNTS OF POTASSIUM IN THE FERTILIZER ON YIELDS OF ONIONS

Plot No.	Fertilizer treatment		Yields	
	Formula	Amount lbs./ acre	1950 lbs./ acre	1951 lbs./ acre
1 (check)	4–12–6	1,500	35,729	32,318
2	4–12–8	1,500	38,377	33,471
3	4–12–10	1,500	45,710	36,805
4	4–12–12	1,500	44,671	40,176
5	4–12–6	2,000	32,673	36,394

Discussion

Analytical data reveal that this Terrebonne clay loam is well supplied with total potash and total organic matter. The exchangeable (normal neutral ammonium acetate) potash is also in fairly good abundance. As shown, an increase in the amounts of potassium supplied led to an increase in yields. It is to be noted that Plots 1 and 2 (4-12-6 and 4-12-8, in equal amounts) gave the same yields approximately, while Plots 3 and 5 (4-12-10 and 4-12-6, in different amounts) as compared to each other also gave quite similar crop yields.

Onions, particularly, seem to have

benefited by an increase of the potassium content of the fertilizer. Maturity at harvest, which is an important factor affecting the keeping quality of onions, has been promoted to a significant degree.

Although these experimental figures cannot be taken as final conclusions, they indicate the possibility of promoting plant growth through increased amounts of potassium applied to soils similar in nature to the one used in these experiments. Analytical data support the hypothesis that potassium in this soil, although abundant in total quantity and fairly abundant in exchangeable form, may be too slowly available to a rapidly growing plant. These conclusions are somewhat in accord with W. A. DeLong's [2] (Macdonald College, Quebec) who, after studying a Greensboro loam, expressed the opinion that "once the available potassium supply of this soil is depleted, replenishment by natural processes is slow. That is, this soil appears essentially to contain but two sources of potassium, the readily available and the strongly fixed." DeLong has also found that application to the Greensboro loam of 130 lbs. of potassium in the fertilizer plus 10 tons of manure has resulted in no appreciable increase in the moderately available fraction of potassium. Following further study of the Greensboro loam, a Ste. Therese clay loam and a Ste. Rosalie sandy clay loam, DeLong has reached the conclusion that the first had fixed 27% of the initial readily available potassium; the second, 42%; and the third, around 80%. These soils, especially Ste. Therese clay loam and Ste. Rosalie sandy clay loam, have much in common with the Terrebonne clay loam studied, at least as concerns the colloidal pedological complex.

With the actual trend of increasing rates of fertilizer applications, this lack of readily available potassium may become more pronounced. As more nitrogen and phosphorus are added to the

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Fig. 1. Effect of potassium content of the fertilizer on the maturation of onions. These onions (Sweet Spanish) fertilized with 1,500 lbs. of 4-12-12 (left) matured 10 days sooner than those fertilized with 2,000 lbs. of 4-12-6 (right). Yields in 1951: left, 40,176 lbs. per acre; right, 36,394 lbs. per acre.

Virginia Revises Its Fertilizer Law

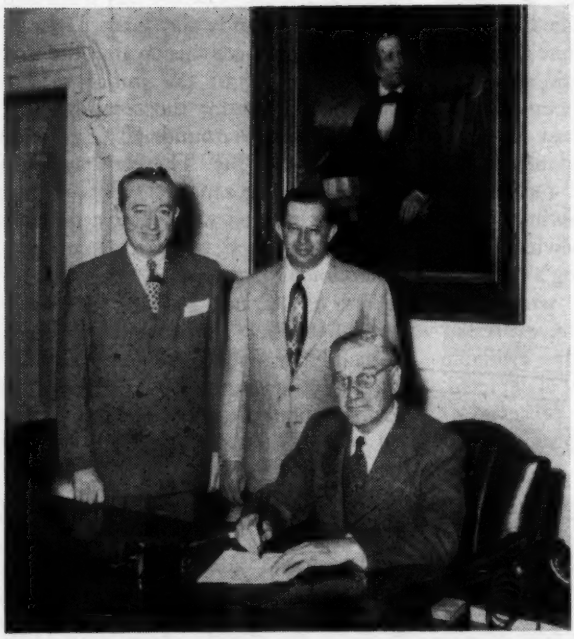

Fig. 1. Governor John S. Battle signs Virginia's new fertilizer law while Dr. Paul D. Sanders (left), Editor of the Southern Planter, and Commissioner of Agriculture Parke C. Brinkley look on.

THE present Virginia Fertilizer Law was enacted about 75 years ago and was adequate to control the distribution of fertilizer and fertilizer materials at that time. The original Act has been amended from time to time to permit the sale of and provide control of new formulas of fertilizer recommended by the State's Experiment Stations. As a result of these many amendments, some sections of the law seem to contradict other sections and are in conflict with the laws of neighboring states.

Since a considerable tonnage of fertilizer moves in interstate shipment, the need for more uniformity in state laws regulating distribution has been recognized by all the states. About five years ago, a Model Fertilizer Law was suggested by a committee of state control officials, agronomists, and experiment station workers. This model law was suggested only as a guide in uniformity, with each state establishing controls to meet its needs on the local level.

About two years ago at a joint meeting of Experiment Station workers and control officials of North Carolina, South Carolina, and Virginia, the fertilizer needs and laws of the three states were reviewed, and a movement was started to bring the laws of the states into closer uniformity. Representatives of the same groups met again in the spring of 1951. During this two-year period, the South Carolina Fertilizer Law was amended, the North Carolina Fertilizer Law was completely revised and amended, and the Virginia Department of Agriculture began a study of the Virginia Law.

Many conferences between the Department of Agriculture, Virginia Experiment Station, Virginia Truck Experiment Station, and the Tobacco Workers Committee were held, and it

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Science and the Cow Look at Pasture Forage as a Feedstuff*

1. The Cow as a Converter of Roughage

By Marshall E. McCullough

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RECENT estimates have shown that about 125 million acres of land in the United States are devoted to the production of pasture and hay. Of this acreage about 75 million constitute the range land of the West, 48 million acres are in pastures, and the rest are devoted to hay and silage. The entire production of this enormous acreage would be useless to man were it not for the ability of cows and sheep to convert it to meat, milk, and wool.

In recent years great strides have been made in the conservation of our greatest natural resource—the soil. Of all conservation practices, none is more effective than the planting of the land in grass and legumes. If this system of "Grassland Farming" is to be successful and our population to be properly fed without increased use of cereals, a more thorough understanding of the functions and use of cows and sheep must become a reality. Such an understanding will enable greater production of roughage with the resulting greater income to farmers and more and higher quality food for everyone.

The four-compartment stomach of the ruminant (cow-sheep-deer) sets it apart from other members of the animal kingdom chiefly due to its ability to utilize fibrous feeds such as pasture forage, hay, straw, and silage. Of primary significance in this ability is the presence of the largest compartment (rumen) at the head of the digestive tract. The rumen of dairy cows varies in its capacity from 40-65 gal., depending upon the size of the cow and the nutritional history of her early life. Essentially, the rumen functions as a fermentation vat where the food materials coming from the mouth undergo a period of fermentation during which the nutrients are converted to a form more useful to the animal.

Connecting the rumen with the small intestines (the site of most food absorption) there are three compartments called the reticulum, the omasum, and the true stomach. The function of the second and third compartments is not fully understood. The reticulum is best noted for its tendency to collect such foreign objects as nails, wire, stones, and such other objects as the cow may pick up in grazing or eating in the barn. The third stomach presses the food and removes a large portion of its water, but this function has not thus far been shown to be of any special importance. The true stomach, or abomasum, serves the cow as the stomach of any other animal. The first secretion of enzymes occurs here and apparently what is called true digestion begins for the first time.

The location of the rumen at the beginning of this system has the advantage that the materials synthesized there may be absorbed by the animal. Most nonruminants have some fermentation in the lower digestive tract, but the fact that it occurs so late in the process pre-

*No. 1 in a series of articles.

Fig. 1. The author and his favorite farm animal team-up to study their favorite subject—pasture forage.

vents it from being of any great value to the animal.

In recent years much interest has been created in the exact mechanism of this fermentation process which makes the cow a good user of roughage that has no food value to man, and enables her to convert it into meat and milk. The literature cited at the end of the article contains excellent reviews of such work. For this paper we shall confine our thinking to the over-all principles that have so far been demonstrated.

The food and water consumed by the cow pass directly to the rumen where they are attacked by microorganisms and fermentation begins. The length of time required for fermentation or breakdown of the roughage depends upon the type of roughage. The completeness of fermentation is apparently determined by the presence or absence of certain compounds such as lignin and the species and number of microorganisms appropriate for the roughage being consumed. Increasing amounts of lignin, as found in more mature pasture herbage and hays, prevent other compounds such as cellulose from becoming accessible to the bacteria. The absence of sufficient carbohydrates, protein, and/or minerals to stimulate the rapid growth and activities of the bacteria may also be a limiting factor. Each type of ration (hay, hay and grain, or pasture) seems to require a characteristic flora for its most efficient utilization. Thus, the common observation that it requires a period of time for cows to become adjusted to a new ration may be explained by this fact.

The fermentation process. Although scientists in many countries have become interested in this process within the last decade, many questions have either not been studied or remain unanswered at this time. While many of the theories that have been advanced are quite interesting, for the purposes of this discussion only those facts and theories which are fairly well understood are discussed.

Cellulose. Perhaps the most striking result of the rumen activity is the conversion of cellulose (measured as crude fiber) into short chain fatty acids —chiefly acetic, propionic, and butyric, and the gases—carbon dioxide and methane. A simplified scheme for this and other conversions is presented in

Fig. 2. This process is amazingly fast (about 6-8 hrs.) and quite efficient. With the rapid production of these acids the pH of the rumen contents would be expected to fall to a very low level and the fermentation process to cease. Such a condition is prevented by the buffering effect of the phosphate and bicarbonate of the saliva. As a further aid to the prevention of a high acidity, a great proportion of the acids are absorbed into the blood stream through the rumen wall.

The process of conversion is greatly aided by frequent regurgitation of the rumen contents into the mouth for mastication. This process commonly called "cud-chewing" is of great importance since it breaks much of the fibrous material into smaller particles and exposes a greater surface area of the food to attack by microorganisms.

Other carbohydrates. The fate of the sugars and starch in the rumen has been the subject of much debate in recent years. Simple sugars such as glucose placed in the rumen disappear at a very rapid rate. Most workers agree that this indicates that the bacteria use such compounds as a source of energy for their rapid growth. It should be emphasized, however, that the dividing line between enough and too much readily available carbohydrates is a narrow one. Recent work in England has shown that the greatest cellulose digestion occurs when there is 0.1-0.2% sugar in the rumen, either more or less being inhibitory. It can be assumed that this small amount of sugar stimulates rapid growth of the bacteria, and cellulose digestion results when other readily available sources of energy are expended. The addition of large amounts of molasses to hay has frequently been found to reduce crude fiber digestion and can probably be explained on this basis. This phenomenon may best be explained by saying that the bacteria use the more readily available sources of energy first and attack the cellulose only as a last resort.

Protein. The rumen bacteria apparently convert much of the nitrogen in the ration into bacterial protein for their own growth and development. The many successful uses of nonprotein nitrogen such as urea in rations for dairy cows point to this ability of the bacteria. Since this fact has been demonstrated it explains why it is gen-

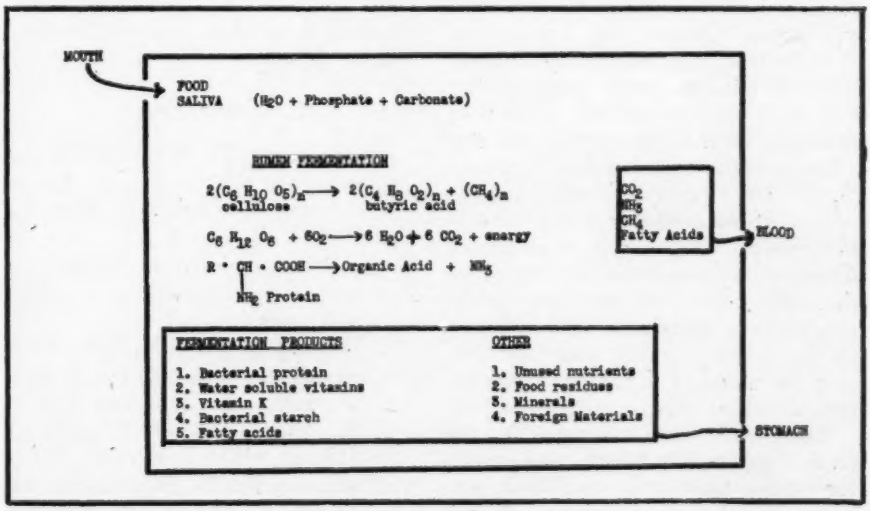

Fig. 2. A schematic drawing showing the flow of food materials into and away from the rumen and the apparent chemical reactions that take place during rumen fermentation.

erally unnecessary to consider the quality of protein in dairy cow rations. The upper limits at which the cow is able to use urea have not been fully determined. It remains necessary, therefore, to provide a large part of the nitrogen as protein, although its source is of little significance. A very interesting cycle is involved in this protein hydrolysis and the breakdown of cellulose. The bacteria utilize a great deal of urea in the cellulose breakdown. To supply this, a portion of the ammonia coming from the protein breakdown is carried in the blood to the liver where it is converted into urea. From the liver, the urea is carried back to the salivary glands where it becomes a part of the saliva and is in turn added to the rumen contents as an aid to the cellulose breakdown.

Synthesized factors. As by-products of rumen activity, many dietary factors are produced and used by the cow. A few of the factors synthesized in the rumen are: Vitamin K, thiamine, riboflavin, niacin, pantothenic acid, biotin, fat, carbohydrate (starchlike compound), protein from nonprotein nitrogen, and unknown dietary factors. Because of this synthesis, it is unnecessary under ordinary conditions to give consideration to supplying the cow with any extra vitamins in her ration. While vitamins A and D are required from an outside source, good quality hay or pasture forage will more than meet her vitamin A requirement, and a few hours in open sunshine will take care of the vitamin D needs.

Fate of the products of digestion in the rumen. The products of rumen fermentation may leave the rumen by three channels: They may pass up the esophagus to the mouth; they may pass to the lower digestive tract; or they may be absorbed into the lymphatic and blood streams.

Earlier reference was made to the passage of food back into the mouth for further mastication and its importance to the fermentation process. Many of the gases go out by this route, although some absorption also occurs.

The material going to the omasum consists of food residues and microorganisms suspended in a solution which contains minerals, fatty acids, vitamins, and ammonia. The subsequent digestion and absorption of these materials provide the cow with the nutrients needed for maintenance, growth, reproduction, and production.

Acetic, propionic, and butyric acids are absorbed into the blood along with some carbon dioxide and ammonia. Of the acids absorbed nearly 80% consist of acetic acid, most of which is removed by the udder for use in milk production.

Summary. We have seen how the cow with her large fermentation vat and billions of microorganisms is able to consume roughage and convert it into milk and meat. This process remains one of the marvels of nature and has only recently come into its rightful place in the field of scientific investigation. It should not be concluded that because of this knowledge, meat and milk enough for an unlimited human population can be produced from roughage alone. In subsequent articles many of the problems encountered in this process of converting roughage to meat and milk will be outlined, and observations on their scope and remedy will be discussed.

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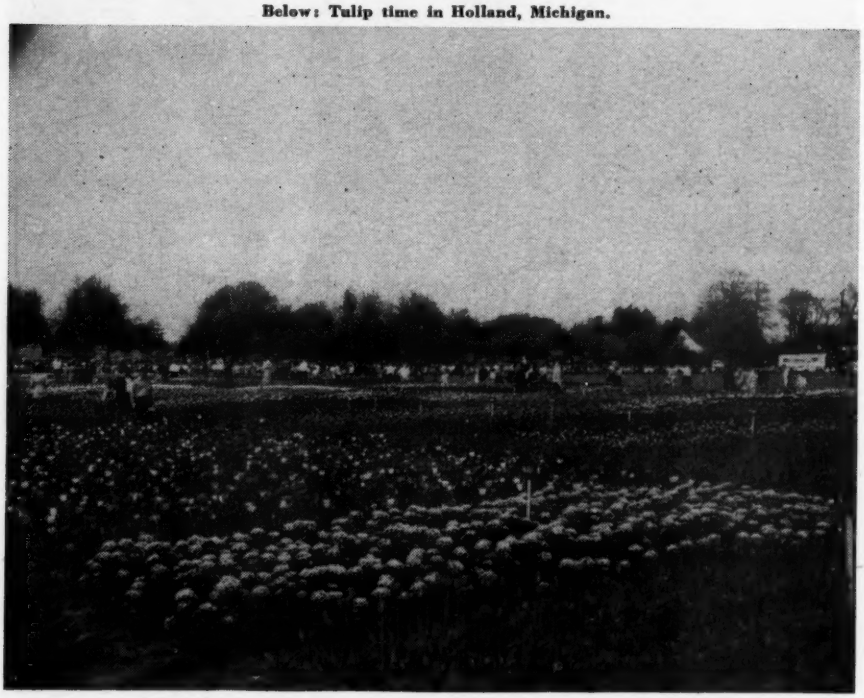
PICTORIAL

Right there, Pa!

Above: It is easy to work in such surroundings.

Below: Tulip time in Holland, Michigan.



Above: Good equipment and good help are half the battle.

Below: Spring brings out the Sunday drivers.

Above: Mutual understanding and confidence.

Below: Sheep-shearing time.

The Editors Talk

The Importance of Grasslands

Whenever an international meeting is called, the subject for discussion assumes a truly great importance. While there has been in this country a tremendous increase in interest in establishing more pastures and improving those now in existence, the forthcoming International Grassland Conference to be held at Pennsylvania State College, August 17-23, places a new emphasis on this phase of our own and the world's agriculture.

It has been definitely established that grassland agriculture is one of the most important factors affecting the future of the world today. It is not only a foundation for a better fed population, but also offers substantial insurance against soil depletion. By itself, it is not a panacea for the farm production problems of the world, but the possibilities for stabilizing agriculture and providing economical livestock production are enormous. With great increases in world population, more and more concern is being directed toward overcoming food shortages. In planning for the future, agricultural leadership is looking to grassland agriculture to help insure an economy of abundance in a world struggling from want.

It might be mentioned here that grassland farming does not mean putting the entire acreage of a farm to grass. It is a system of farming and ranching in which grasses and legumes are included in proper proportions for hay, silage, pasture, and soil conservation and improvement for high production and profitable returns.

Agricultural research and educational authorities are placing great emphasis on a sound grassland program as one of the best and cheapest sources for the proteins, minerals, and vitamins on which animal life so heavily depends. Nearly all pasture soils of the humid sections of the United States, for example, are deficient in nitrogen, phosphorus, potassium, and calcium. Sound land management calls for intelligent use of fertilizers, manure, and lime—all of which are essential in good pasture management.

The meeting at Pennsylvania State College will be the Sixth International Grassland Congress and the first to be held in the United States. The others were held in Germany in 1927, Sweden and Denmark 1930, Switzerland 1934, Great Britain 1937, and in the Netherlands in 1949. Governments of more than 60 countries have been invited to send official delegates, and other persons, institutions, and organizations interested in the grassland movement have been invited to participate. General sessions will hear leaders of grassland work throughout the world discuss such subjects as: Grassland Resources and Potentials of the World; Putting Grassland Information to Work; Conservation and Improvement of Soil and Water Resources with Grass; Pressures on Native Pasture Lands Throughout the World; Interdependence of Grassland and Livestock in Agricultural Production; Problems in Development of a Grassland Program in the American Tropics; Grasslands for Recreation; and Social and Economic Aspects of Grassland Development. Sectional discussions will include: Genetics and

Breeding; Improvement and Management of Pastures, Meadows, and Turf; Improvement and Management of Range Lands; Ecology and Physiology; Soil Management and Fertilization; Seed Production and Distribution; Soil and Water Conservation; Harvesting and Preservation of Forage; Use of Forage in Livestock Feeding; Machinery; Experimental Procedure in Grassland Research; and Improvement and Management of Tropical Grasslands.

There will be visits to local points of scientific interest. After the Congress, tours covering a period of two weeks have been arranged to cover representative grassland areas of the Northeast including Canada, the Midwest, South, and West.

Grasslands of the world occupy more than half the earth's entire land surface. There are one billion acres of grazing lands in the United States. Hay and pasture provide more than half the nutrients consumed by all livestock. The world's great food problem won't be solved until ways for getting more meat per acre are found. Research must learn how to do it. Therefore, Pennsylvania State College during the week of August 17-23 is a focal point of world interest. It is certain that much for the betterment of mankind will result from this international meeting.

Our Cover Picture

The corn ears and roots shown on the cover of this issue came from a fertilization experiment on the farm of George Deatherage near Oblong, Illinois, results of which are discussed in the story by P. E Johnson of the University of Illinois, beginning on page six

To grow good quality corn, it must ripen while the stalk is still green and the roots are functioning, such as that shown on the left in the cover illustration. This stalk and ear came from a plot with a heavy broadcast application of potash (225 lbs. K_2O) plus 60 lbs. of nitrogen sidedressed on clover sod, the soil having been adequately supplied with phosphorus.

The chaffy ear and rotted stalk and roots on the right came from a plot with nitrogen alone and illustrate the final result of extreme potash starvation. Note that most roots were rotted off by October 20, when this color photograph was taken. Also, internal parts of the lower stalk were decayed, especially at the nodes. Stalks often break over at these decayed nodal areas or blow down because of weak root anchorage.

Earlier in the season, these nodal tissues showed abnormal, darkened areas due to iron accumulations which clog fibrovascular bundles. All water and nutrients which are taken up by the roots must pass through these nodes on the way to the leaves. The sugars manufactured in leaves by photosynthesis again must pass through the nodes before being translocated to growing points or stored in the ear. If the vascular bundles are clogged at the nodes, a normal ear cannot develop.

The exact cause of potash-starved corn stalks and roots decaying prematurely is still a matter of debate. We know that when corn leaves show brown marginal scorch and yellowish areas between veins, which are typical external symptoms of potash starvation, tissue tests indicate reserves of nitrates and phosphates in the plant sap. Also, there is an accumulation of unassimilated sugars. It would appear that such a chemical condition in the plant sap would be a perfect medium for the growth of bacteria or molds which get into plant cells.

These observations help to explain certain types of leaning and broken stalks often found when available potassium is low in respect to the nitrogen supply. Lodged corn is not a sure sign of potash starvation, but when corn is potash-starved and has plenty of nitrogen, it is most likely to lodge.

Season Average Prices Received by Farmers for Specified Commodities *

Crop Year	Cotton Cents per lb. Aug.-July	Tobacco Cents per lb.	Potatoes Cents per bu. July-June	Sweet Potatoes Cents per bu. July-June	Corn Cents per bu. Oct.-Sept.	Wheat Cents per bu. July-June	Hay [1] Dollars per ton July-June	Cottonseed Dollars per ton July-June	Truck Crops ....
Av. Aug. 1909–July 1914....	12.4	10.0	69.7	87.8	64.2	88.4	11.87	22.55	....
1926.....	12.5	17.9	131.4	117.4	74.5	121.7	13.24	22.04	....
1927.....	20.2	20.7	101.9	109.0	85.0	119.0	10.29	34.83	....
1928.....	18.0	20.0	53.2	118.0	84.0	99.8	11.22	34.17	....
1929.....	16.8	18.3	131.6	117.1	79.9	103.6	10.90	30.92	....
1930.....	9.5	12.8	91.2	108.1	59.8	67.1	11.06	22.04	....
1931.....	5.7	8.2	46.0	72.6	32.0	39.0	8.69	8.97	....
1932.....	6.5	10.5	38.0	54.2	31.9	38.2	6.20	10.33	....
1933.....	10.2	13.0	82.4	69.4	52.2	74.4	8.09	12.88	....
1934.....	12.4	21.3	44.6	79.8	81.5	84.8	13.20	33.00	....
1935.....	11.1	18.4	59.3	70.3	65.5	83.2	7.52	30.54	....
1936.....	12.4	23.6	114.2	92.9	104.4	102.5	11.20	33.36	....
1937.....	8.4	20.4	52.9	78.0	51.8	96.2	8.74	19.51	....
1938.....	8.6	19.6	55.7	69.8	48.6	56.2	6.78	21.79	....
1939.....	9.1	15.4	69.7	73.4	56.8	69.1	7.94	21.17	....
1940.....	9.9	16.0	54.1	85.4	61.8	68.2	7.59	21.73	....
1941.....	17.0	26.4	80.8	92.2	75.1	94.4	9.70	47.65	....
1942.....	19.0	36.9	117.0	118.0	91.7	110.0	10.80	45.61	....
1943.....	19.9	40.5	131.0	206.0	112.0	136.0	14.80	52.10	....
1944.....	20.7	42.0	150.0	190.0	109.0	141.0	16.50	52.70	....
1945.....	22.5	36.6	143.0	204.0	127.0	150.0	15.10	51.10	....
1946.....	32.6	38.2	124.0	218.0	156.0	191.0	16.70	72.00	....
1947.....	31.9	38.0	162.0	217.0	216.0	229.0	17.60	85.90	....
1948.....	30.4	48.2	155.0	222.0	129.0	200.0	18.45	67.20	....
1949.....	28.6	45.9	128.0	214.0	124.0	188.0	16.50	43.40	....
1950.....	40.1	51.6	91.6	173.0	153.0	200.0	16.70	86.50	....
1951									
May.....	42.45	39.8	109.0	209.0	164.0	211.0	18.15	101.00	....
June.....	42.02	49.0	108.0	210.0	162.0	208.0	16.85	95.60	....
July.....	39.11	49.5	118.0	219.0	163.0	205.0	15.45	78.00	....
August.....	34.60	47.7	117.0	273.0	165.0	205.0	15.65	69.10	....
September...	33.73	52.4	123.0	287.0	165.0	207.0	16.55	66.10	....
October.....	36.21	57.7	139.0	271.0	164.0	210.0	17.15	69.90	....
November....	41.00	50.0	174.0	280.0	162.0	219.0	18.35	72.70	....
December....	40.34	51.0	193.0	305.0	169.0	222.0	19.65	71.50	....
1952									
January.....	38.70	46.2	207.0	347.0	168.0	220.0	20.75	70.10	....
February....	37.25	33.8	205.0	357.0	166.0	218.0	20.65	67.10	....
March.....	36.72	23.5	216.0	383.0	165.0	220.0	20.35	61.50	....
April.....	37.30	15.0	231.0	416.0	168.0	218.0	20.05	60.80	....
Index Numbers (Aug. 1909—July 1914 = 100)									
1926.....	101	179	189	134	116	138	112	98	139
1927.....	163	207	146	124	132	135	87	154	127
1928.....	145	200	76	134	131	113	95	152	154
1929.....	135	183	189	133	124	117	92	137	137
1930.....	77	128	131	123	93	76	93	98	129
1931.....	46	82	66	83	50	44	73	40	115
1932.....	52	105	55	62	50	43	52	46	102
1933.....	82	130	118	79	81	84	68	57	91
1934.....	100	213	64	91	127	96	111	146	95
1935.....	90	184	85	80	102	94	63	135	119
1936.....	100	236	164	106	163	116	94	148	104
1937.....	68	204	76	89	81	109	74	87	110
1938.....	69	196	80	79	76	64	57	97	88
1939.....	73	154	100	84	88	78	67	94	91
1940.....	80	160	78	97	96	77	64	96	111
1941.....	137	264	116	105	117	107	82	211	129
1942.....	153	369	168	134	143	124	91	202	163
1943.....	160	405	188	235	174	154	125	231	245
1944.....	167	420	214	216	170	160	139	234	212
1945.....	181	366	205	232	198	170	127	227	207
1946.....	263	382	178	248	212	209	141	319	182
1947.....	257	380	232	248	336	259	148	381	226
1948	245	482	222	253	201	226	155	298	214
1949.....	231	459	184	244	193	213	139	192	201
1950.....	323	516	131	197	238	226	141	384	185
1951									
May.....	342	398	156	238	255	239	153	448	239
June.....	339	490	155	239	252	235	142	424	189
July.....	315	495	169	249	254	232	130	346	204
August.....	279	477	168	311	257	232	132	306	181
September...	272	524	176	327	257	234	139	293	161
October.....	292	577	188	309	255	238	144	310	171
November...	331	500	250	319	252	248	155	322	249
December....	325	510	277	347	263	251	166	317	331
1952									
January.....	312	462	297	395	262	249	175	311	337
February.....	300	338	294	407	259	247	174	298	217
March.....	296	235	310	436	257	249	171	273	265
April.....	301	150	331	474	262	247	169	270	308

Wholesale Prices of Ammoniates

	Nitrate of soda bulk per unit N	Sulphate of ammonia bulk per unit N	Cottonseed meal S. E. Mills per unit N	Fish scrap, dried 11–12% ammonia, 15% bone phosphate, f.o.b. factory bulk per unit N	Tankage 11% ammonia, 15% bone phosphate, f.o.b. Chicago, bulk, per unit N	High grade ground blood, 16–17% ammonia, Chicago, bulk, per unit N
1910–14	$2.68	$2.85	$3.50	$3.53	$3.37	$3.52
1926	3.06	2.41	4.40	4.95	4.36	4.90
1927	3.01	2.26	5.07	5.87	4.32	5.70
1928	2.67	2.30	7.06	6.63	4.92	6.00
1929	2.57	2.04	5.64	5.00	4.61	5.72
1930	2.47	1.81	4.78	4.96	3.79	4.58
1931	2.34	1.46	3.10	3.95	2.11	2.46
1932	1.87	1.04	2.18	2.18	1.21	1.36
1933	1.52	1.12	2.95	2.86	2.06	2.46
1934	1.52	1.20	4.46	3.15	2.67	3.27
1935	1.47	1.15	4.59	3.10	3.06	3.65
1936	1.53	1.23	4.17	3.42	3.58	4.25
1937	1.63	1.32	4.91	4.66	4.04	4.80
1938	1.69	1.38	3.69	3.76	3.15	3.53
1939	1.69	1.35	4.02	4.41	3.87	3.90
1940	1.69	1.36	4.64	4.36	3.33	3.39
1941	1.69	1.41	5.50	5.32	3.76	4.43
1942	1.74	1.41	6.11	5.77	5.04	6.76
1943	1.75	1.42	6.30	5.77	4.86	6.62
1944	1.75	1.42	7.68	5.77	4.86	6.71
1945	1.75	1.42	7.81	5.77	4.86	6.71
1946	1.97	1.44	11.04	7.38	6.60	9.33
1947	2.50	1.60	12.72	10.66	12.63	10.46
1948	2.86	2.03	12.94	10.59	10.84	9.85
1949	3.15	2.29	10.11	13.18	10.73	10.62
1950	3.00	1.95	11.01	11.70	10.21	9.36
1951						
May	3.13	1.88	13.84	10.41	10.09	10.25
June	3.13	1.88	13.53	9.98	8.87	8.50
July	3.13	2.03	12.37	10.06	8.68	8.56
August	3.13	2.07	11.94	10.41	8.66	8.66
September	3.13	2.07	11.50	10.78	9.26	9.26
October	3.13	2.07	12.85	11.28	10.56	10.32
November	3.34	2.07	13.93	11.28	10.39	10.25
December	3.34	2.07	14.27	11.28	10.08	10.02
1952						
January	3.34	2.07	14.27	11.28	10.39	12.16
February	3.34	2.07	14.27	11.28	11.61	11.08
March	3.34	2.07	14.26	11.28	9.71	9.04
April	3.34	2.07	14.26	11.28	8.80	8.05
	Index Numbers (1910-14 = 100)					
1926	113	84	126	140	129	139
1927	112	79	145	166	128	162
1928	100	81	202	188	146	170
1929	96	72	161	142	137	162
1930	92	64	137	141	112	130
1931	88	51	89	112	63	70
1932	71	36	62	62	36	39
1933	59	39	84	81	97	71
1934	59	42	127	89	79	93
1935	57	40	131	88	91	104
1936	59	43	119	97	106	131
1937	61	46	140	132	120	122
1938	63	48	105	106	93	100
1939	63	47	115	125	115	111
1940	63	48	133	124	99	96
1941	63	49	157	151	112	126
1942	65	49	175	163	150	192
1943	65	50	180	163	144	189
1944	65	50	219	163	144	191
1945	65	50	223	163	144	191
1946	74	51	315	209	196	265
1947	93	56	363	302	374	297
1948	107	71	370	300	322	280
1949	117	80	289	373	318	302
1950	112	68	315	331	303	266
1951						
May	117	66	395	295	299	291
June	117	66	387	283	263	241
July	117	71	353	285	258	243
August	117	73	341	295	257	246
September	117	73	329	305	275	263
October	117	73	365	320	313	293
November	125	73	398	320	308	291
December	125	73	408	320	299	285
1952						
January	122	73	408	320	308	345
February	125	73	408	320	344	315
March	125	73	407	320	288	257
April	125	73	407	320	261	229

Wholesale Prices of Phosphates and Potash * *

	Superphosphate, Baltimore, per unit	Florida land pebble, 68% f.o.b. mines, bulk, per ton	Tennessee phosphate rock, 75% f.o.b. mines, bulk, per ton	Muriate of potash bulk, per unit, c.i.f. Atlantic and Gulf ports[1]	Sulphate of potash in bags, per unit, c.i.f. Atlantic and Gulf ports[1]	Sulphate of potash magnesia, per ton, c.i.f. Atlantic and Gulf ports[1]	Manure salts bulk, per unit, c.i.f. Atlantic and Gulf ports[1]
1910–14	$0.536	$3.61	$4.88	$0.714	$0.953	$24.18	$0.657
1926	.598	3.20	5.57	.596	.854	23.58	.537
1927	.525	3.09	5.50	.646	.924	25.55	.586
1928	.580	3.12	5.50	.669	.957	26.46	.607
1929	.609	3.18	5.50	.672	.962	26.59	.610
1930	.542	3.18	5.50	.681	.973	26.92	.618
1931	.485	3.18	5.50	.681	.973	26.92	.618
1932	.458	3.18	5.50	.681	.963	26.90	.618
1933	.434	3.11	5.50	.662	.864	25.10	.601
1934	.487	3.14	5.67	.486	.751	22.49	.483
1935	.492	3.30	5.69	.415	.684	21.44	.444
1936	.476	1.85	5.50	.464	.708	22.94	.505
1937	.510	1.85	5.50	.508	.757	24.70	.556
1938	.492	1.85	5.50	.523	.774	15.17	.572
1939	.478	1.90	5.50	.521	.751	24.52	.570
1940	.516	1.90	5.50	.517	.730	24.75	.573
1941	.547	1.94	5.64	.522	.780	25.55	.367
1942	.600	2.13	6.29	.522	.810	25.74	.205
1943	.631	2.00	5.93	.522	.786	25.35	.195
1944	.645	2.10	6.10	.522	.777	25.35	.195
1945	.650	2.20	6.23	.522	.777	25.35	.195
1946	.671	2.41	6.50	.508	.769	24.70	.190
1947	.746	3.05	6.60	.432	.706	18.93	.195
1948	.764	4.27	6.60	.397	.681	14.14	.195
1949	.770	3.88	6.22	.397	.703	14.14	.195
1950	.763	3.83	5.47	.371	.716	14.33	.195
1951							
May	.810	3.98	5.47	.420	.796	16.00	.210
June	.810	3.98	5.47	.355	.708	13.44	.176
July	.810	3.98	5.47	.389	.768	14.72	.193
August	.810	3.98	5.47	.389	.768	14.72	.193
September	.810	3.98	5.47	.386	.768	14.72	.193
October	.820	3.98	5.47	.386	.768	14.72	.193
November	.820	3.98	5.47	.386	.768	14.72	.193
December	.820	3.98	5.47	.420	.827	16.00	.210
1952							
January	.820	3.98	5.47	.420	.827	16.00	.210
February	.820	3.98	5.47	.420	.827	16.00	.210
March	.832	3.98	5.47	.420	.827	16.00	.210
April	.840	3.98	5.47	.420	.827	16.00	.210
	Index Numbers (1910-14 = 100)						
1926	112	88	114	83	90	98	82
1927	100	86	113	90	97	106	89
1928	108	86	113	94	100	109	92
1929	114	88	113	94	101	110	93
1930	101	88	113	95	102	111	94
1931	90	88	113	95	102	111	94
1932	85	88	113	95	101	111	94
1933	81	86	113	93	91	104	91
1934	91	87	110	68	79	93	74
1935	92	91	117	58	72	89	68
1936	89	51	113	65	74	95	77
1937	95	51	113	71	79	102	85
1938	92	51	113	73	81	104	87
1939	89	53	113	73	79	101	87
1940	96	53	113	72	77	102	87
1941	102	54	110	73	82	106	87
1942	112	59	129	73	85	106	84
1943	117	55	121	73	82	105	83
1944	120	58	125	73	82	105	83
1945	121	61	128	73	82	105	83
1946	125	67	133	71	81	102	82
1947	139	84	135	70	74	78	83
1948	143	118	135	67	72	58	83
1949	144	108	128	67	74	58	83
1950	142	106	112	68	75	59	83
1951							
May	151	110	112	75	84	66	85
June	151	110	112	65	74	56	80
July	151	110	112	70	81	61	82
August	151	110	112	70	81	61	82
September	151	110	112	70	81	61	82
October	153	110	112	70	81	61	82
November	153	110	112	70	81	61	82
December	153	110	112	75	87	66	85
1952							
January	153	110	112	75	87	66	85
February	153	110	112	75	87	66	85
March	155	110	112	75	87	66	85
April	157	110	112	75	87	66	85

Combined Index Numbers of Prices of Fertilizer Materials, Farm Products and All Commodities

	Farm prices*	Prices paid by farmers for commodities bought*	Wholesale prices of all commodities†	Fertilizer material‡	Chemical ammoniates	Organic ammoniates	Superphosphate	Potash**
1926.....	146	150	146	119	94	135	112	86
1927.....	141	148	139	116	89	150	100	94
1928.....	149	152	141	121	87	177	108	97
1929.....	148	150	139	114	79	146	114	97
1930.....	125	140	126	105	72	131	101	99
1931.....	87	119	107	83	62	83	90	99
1932.....	65	102	95	71	46	48	85	99
1933.....	70	104	96	70	45	71	81	95
1934.....	90	118	109	72	47	90	91	72
1935.....	109	123	117	70	45	97	92	63
1936.....	114	123	118	73	47	107	89	69
1937.....	122	130	126	81	50	129	95	75
1938.....	97	122	115	78	52	101	92	77
1939.....	95	121	112	79	51	119	89	77
1940.....	100	122	115	80	52	114	96	77
1941.....	123	130	127	86	56	130	102	77
1942.....	158	149	144	93	57	161	112	77
1943.....	192	165	151	94	57	160	117	77
1944.....	196	174	152	96	57	174	120	76
1945.....	206	180	154	97	57	175	121	76
1946.....	234	197	177	107	62	240	125	75
1947.....	275	231	222	130	74	362	139	72
1948.....	285	250	241	134	89	314	143	70
1949.....	249	240	226	137	99	319	144	70
1950.....	256	246	236	132	89	314	142	72
1951								
May.....	305	272	266	139	91	334	151	78
June.....	301	272	265	134	91	311	151	69
July.....	294	271	261	135	93	297	151	74
August....	292	271	258	135	94	294	151	74
September.	291	271	258	135	94	300	151	73
October...	296	272	259	140	94	335	153	73
November.	301	274	259	143	98	343	153	73
December..	305	273	258	144	98	342	153	78
1952								
January...	300	275	258	144	98	347	153	78
February..	289	278	255	146	98	365	153	78
March....	288	277	251	144	98	336	155	78
April.....	290	277	251	142	98	322	157	78

* U. S. D. A. figures, revised January 1950. Beginning January 1946 farm prices and index numbers of specific farm products revised from a calendar year to a crop-year basis. Truck crops index adjusted to the 1924 level of the all-commodity index.

† Department of Labor index converted to 1910-14 base.

‡ The Index numbers of prices of fertilizer materials are based on original study made by the Department of Agricultural Economics and Farm Management, Cornell University, Ithaca, New York. These indexes are complete since 1897. The series was revised and reweighted as of March 1940 and November 1942.

[1] Beginning July 1949, baled hay prices reduced by $4.75 a ton to be comparable to loose hay prices previously quoted.

[2] All potash salts now quoted F.O.B. mines only; manure salts since June 1941, other carriers since June 1947.

**** The weighted average of prices actually paid for potash is lower than the annual average because since 1926 over 90% of the potash used in agriculture has been contracted for during the discount period. The maximum discount is now 16%. Applied to muriate of potash, a price slightly above $.353 per unit K_2O thus more nearly approximates the annual average than do prices based on arithmetical averages of monthly quotations.**

REVIEWS

This section contains a short review of some of the most practical and important bulletins, and lists all recent publications of the United States Department of Agriculture, the State Experiment Stations, and Canada, relating to Fertilizers, Soils, Crops, and Economics. A file of this department of BETTER CROPS WITH PLANT FOOD would provide a complete index covering all publications from these sources on the particular subjects named.

Fertilizers

"Commercial Fertilizers, Report for 1951," Agr. Exp. Sta., New Haven, Conn., Bul. 551, Dec. 1951.

"Kansas Fertilizer Trends—Report of the Kansas State Board of Agriculture," State Board of Agr., Topeka, Kans., Vol. LXXI, No. 307, March, 1952.

"Fertilizer Analyses and Registrations, 1951," Dept. of Agr., Dairy and Food, St. Paul, Minn.

"Fruit Tree Fertilization with Nitrogen," Agr. Exp. Sta., Univ. of Mo., Columbia, Mo., Bul. 550, Apr. 1951, A. E. Murneek.

"Magnesium in Plants and Soils," Agr. Exp. Sta., Rutgers Univ., New Brunswick, N. J., Bul. 760, Nov. 1951, F. E. Bear, A. L. Prince, S. J. Toth, and E. R. Purvis.

"Fertilizer Recommendations 1952," N. C. State College, Raleigh, N. C., E. R. Collins.

"State of Oklahoma Seed Law, Commercial Feed Law, Fertilizer Law, and Their Rules and Regulations," Dept. of Agr., Seed, Feed and Fert. Div., Oklahoma City, Okla.

"South Carolina Fertilizer & Fertilizer Materials Report, July 1-December 31, 1951," Clemson Agr. College, Clemson, S. C., Feb. 29, 1952.

"Distribution of Fertilizer Sales in Texas, January 1-June 30, 1951," Agr. Exp. Sta., Texas A & M College, College Station, Texas, P. R. 1399, Sept. 7, 1951, J. F. Fudge.

"The Fertilizer Situation for 1951-1952," Pro. & Mktg. Admin., USDA, Wash., D. C., Feb. 1952.

Soils

"Irrigation Methods to Conserve Soil and Water on Steep Lands," Ext. Serv., Univ. of Calif., Berkeley, Calif., Cir. 177, June 1951, L. N. Brown.

"Costs of Sprinkler Irrigation on Idaho Farms," Agr. Exp. Sta., Univ. of Ida., Moscow, Ida., Bul. No. 287, Oct. 1951, M. C. Jensen and R. C. Bevan.

"Test Your Soil—Know What It Needs," Ext. Serv., Okla. A & M College, Stillwater, Okla., Cir. 566, W. Chaffin and R. O. Woodward.

"Cost of Water for Irrigation on the High Plains," Agr. Exp. Sta., Tex. A & M College, College Station, Tex., Bul. 745, Feb. 1952, A. C. Magee, W. C. McArthur, C. A. Bonnen, and W. F. Hughes.

"Soil Survey: The Los Banos Area California," Agr. Res. Admin., USDA, Wash., D. C., Series 1939, No. 12, Jan. 1952, R. C. Cole, R. A. Gardner, F. F. Harradine, R. O. Kissling, J. W. Kingsbury, and L. G. Thompson.

Crops

"Cotton Production Practices in the Sand Mountain Area of Alabama," Agr. Exp. Sta., Ala. Poly. Inst., Auburn, Ala., Cir. No. 101, Aug. 1951, M. White.

"Cotton Production Practices in the Piedmont Area of Alabama," Agr. Exp. Sta., Ala. Poly. Inst., Auburn, Ala., Cir. 102, Sept. 1951, M. White.

"Cotton Production Practices in the Upper Coastal Plain Area of Alabama," Agr. Exp. Sta., Ala. Poly. Inst., Auburn, Ala., Cir. No. 103, Oct. 1951, R. W. Robinson.

"Cold Damage to Camellias, Winter of 1950-51," Agr. Exp. Sta., Ala. Poly. Inst., Auburn, Ala., Cir. No. 107, Oct. 1951, M. J. Funchess.

"Utilization of Phosphorus from Barley Residues in Calcareous Soils," Agr. Exp. Sta., Univ. of Ariz., Tucson, Ariz., Tech. Bul. 123, Oct. 1951, W. H. Fuller and R. N. Rogers.

"Rice Varietal Tests, 1950-1951," Agr. Exp. Sta., Univ. of Ark., Fayetteville, Ark., Mimeo. Series No. 7, Dec. 1951, C. R. Adair and E. M. Cralley.

"Prune Production in California," Ext. Serv., Univ. of Calif., Berkeley, Calif., Cir. 180, C. J. Hansen.

"Lawn Planting and Care," Ext. Serv., Univ. of Calif., Berkeley, Calif., Cir. 181, Oct. 1951, H. M. Butterfield, W. Schoonover, and H. W. Shepherd.

"Apple Growing in California," Ext. Serv., Univ. of Calif., Berkeley, Calif., Cir. 178, Sept. 1951, F. W. Allen.

"Deciduous Orchards in California Winters," Ext. Serv., Univ. of Calif., Berkeley, Calif., Cir. 179, Aug. 1951, W. H. Chandler and D. S. Brown.

"Winter Wheat Improvement in Ontario—Ninth Annual Report," Dept. of Agr., Ottawa, Ont., Canada, March 1952.

"Vegetable Garden Production Guide," Ext. Serv., Univ. of Fla., Gainesville, Fla., Cir. 104, Sept. 1951.

"Cotton Variety Tests, 1951 with Three-Year Averages 1949-1951," Agr. Exp. Sta., Univ. of Ga., Experiment, Ga., Press Bul. 634, Feb. 1952, B. S. Hawkins, T. E. Steele, W. W. Ballard, and S. V. Stacy.

"Effect of Spacing and Fertilization on the Yield of Asparagus," Agr. Exp. Sta., Univ. of Ga., Experiment, Ga., Cir. 166, Sept. 1951, F. F. Cowart, H. L. Cochran, and B. B. Brantley.

"Grass Utilization and Pasture Management Investigations for 1946-50, Report No. 1," Agr. Exp. Sta., Fort Hays Branch Sta., Manhattan, Kans., Cir. 276, Dec. 1951, F. B. Kessler, L. C. Aicher, and F. E. Meenen.

"Fifty-seventh Annual Report Agricultural Experiment Station, University of Minnesota, July 1, 1949 to June 30, 1950," Univ. of Minn., St. Paul, Minn., Jan. 1952.

"Care of House Plants," Agr. Exp. Sta., Rutgers Univ., New Brunswick, N. J., Cir. 542, Oct. 1951, H. M. Biekart.

"Field Crop Recommendations 1952," Ext. Serv., Rutgers Univ., New Brunswick, N. J., Leaf. 71, Nov. 1951, J. E. Baylor.

"Oklahoma Corn Performance Tests, Summary: 1948, 1949, 1950, and 1951," Agr. Exp. Sta., Okla. A & M College, Stillwater, Okla., Misc. Pub. No. MP-26, March 1952, J. S. Brooks and H. Pass.

"Mechanizing Cotton for Low-cost Production," Agr. Exp. Sta., Okla. A & M College, Stillwater, Okla., Bul. No. B-382, March 1952, R. T. Humphreys, J. M. Green, and E. S. Oswalt.

"Grass Silage in Oklahoma," Agr. Exp. Sta., Okla. A & M College, Stillwater, Okla., Cir. No. C-135, Feb. 1952.

"Oklahoma Farm Production Prospects in 1952," Agr. Exp. Sta., Okla. A & M College, Stillwater, Okla., Mimeo. Cir. M-230, Dec. 1951.

"Hybrid Corn Strains Recommended for 1952 Based on Results of the Oklahoma Corn Performance Tests 1946-1951," Okla. A & M College, Stillwater, Okla., Mimeo. Cir. M-231, Jan. 1952, J. S. Brooks and H. Pass.

"Talent Alfalfa," Agr. Exp. Sta., Oreg. State College, Corvallis, Oreg., Sta. Bul. 511, March 1952, H. A. Schoth, L. G. Gentner, and H. H. White.

"United for Service, Annual Report of the Rhode Island Agricultural Extension Service, University of Rhode Island," Ext. Serv., Univ. of R. I., Kingston, R. I., Bul. No. 139, Apr. 1951, H. O. Stuart.

"Vegetable Varieties for the Rhode Island Grower," Ext. Serv., Univ. of R. I., Kingston, R. I., Mimeo Cir. #69, Rev. Mar. 1, 1951, C. J. Kneeland.

"Cotton Production Insect and Disease Control, South Carolina—1952," Ext. Serv., Clemson, Agr. College, Clemson, S. C., Cir. 367, Jan. 1952.

"Progress of Grassland Farming in South Carolina," Ext. Serv., Clemson Agr. College, Clemson, S. C., Cir. 373, March 1952, H. A. Woodle, E. C. Turner, and W. H. Craven.

"Agricultural Research in South Dakota, Sixty-fourth Annual Station Report July 1, 1950 to June 30, 1951," Agr. Exp. Sta., S. D. State College, Brookings, S. D.

"Effect of Crimson Clover on the Yield and Chemical Composition of Cool Season Grasses," Agr. Exp. Sta., Texas A & M College, College Station, Texas, P. R. 1403, Sept. 25, 1951, E. C. Holt, R. C. Potts, and L. C. Kapp.

"El Paso Valley Cotton Variety Test, 1950," Agr. Exp. Sta., Texas A & M College, College Station, Texas, P. R. 1404, Sept. 28, 1951, L. S. Stith and P. J. Lyerly.

"American-Egyptian Cotton Variety Tests at the El Paso Valley Experiment Station, 1949-50," Agr. Exp. Sta., Texas A & M College, College Station, Texas, P. R. 1406, Oct. 8, 1951, L. S. Stith, P. J. Lyerly, and R. H. Peebles.

"Cotton Variety Tests in the Lower Rio Grande Valley, 1951," Agr. Exp. Sta., Texas A & M College, College Station, Texas, P. R. 1408, Oct. 9, 1951, J. L. Hubbard, C. A. Burleson, and W. R. Cowley.

"Tung Production," USDA, Wash., D. C., Farmers' Bul. No. 2031, Dec. 1951, G. F. Potter and H. L. Crane.

"Seed-flax Production in the North Central States," USDA, Wash., D. C., Farmers' Bul. No. 2036, Jan. 1952, J. O. Culbertson, T. E. Stoa, R. S. Dunham, H. H. Flor, and J. J. Christensen.

Economics

"Service Relationships of Farmers in Lincoln County, Oklahoma," Agr. Exp. Sta., Okla. A & M College, Stillwater, Okla., Bul. No. B-383, March 1952, J. C. Belcher.

"The Oklahoma A & M College Farm Lease Form," Agr. Exp. Sta., Okla. A & M College, Stillwater, Okla., Misc. Pub. No. MP-25, March 1952, K. C. Davis.

"Oregon's Long-term Trends in Agriculture (1925-1929 to 1945-1949)," Ext. Serv., Oreg. State College, Corvallis, Oreg., Ext. Bul. 722, Nov. 1951, L. R. Breithaupt and E. Horrell.

"Planning for Profitable Grassland on Dairy Farms in Central Pennsylvania," Bul. 545, Oct. 1951; "Planning for Profitable Grassland on Dairy Farms in Central Pennsylvania," Bul. 545P, Oct. 1951; Agr. Exp. Sta., Pa. State College, State College, Pa., K. H. Myers and R. G. Campbell.

"An Economic Study of Family-Sized Farms in Puerto Rico IV. Aibonito, Barranquitas, and Corozal Farm Security Administration Farms 1943-44, 1944-45," Agr. Exp. Sta., Univ. of P. R., Rio Piedras, P. R., Bul. No. 80, Feb. 1951, G. Serra and M. Pinero.

"An Economic Study of Family-Sized Farms in Puerto Rico, V. Victoria Farm Security Ad-

ministration Farms, 1945-46, 1946-47," Agr. Exp. Sta., Univ. of P. R., Rio Piedras, P. R., Bul. No. 81, March 1951, G. Serra and M. Pinero.

"The Agricultural Conservation Program Handbook (1061) for 1952 for: Ala., Calif., Colo., Fla., Ga., Ida., Ill., Iowa, Kans., Me., Miss., Mo., Nebr., N. H., N. Mex., N. Y., Okla., Pa., Tenn., Tex., Wyo.," USDA, Pro. & Mktg. Adm., Wash., D. C.

"Planning Production in 1952, 1952 Prospective Acreages and Goal Comparisons," USDA, Wash., D. C., Mar. 20, 1952.

Berry Buyers Pick Their Own

A NEW HAMPSHIRE strawberry grower who allowed families to go into his berry fields to do the work —and enjoy the savings and the fun— of berry picking made a better profit than he did from berries picked by hired labor. The State Extension Service, reporting this to the U. S. Department of Agriculture, said that several growers have followed this innovation. Extension headquarters in Washington is passing on the information so that growers elsewhere may experiment with this simplification of marketing and labor management.

The grower found that he could sell his berries to customers who came to his farm and picked their own for a net of 23 cents a box, says the New Hampshire Extension Service. For the remainder of the crop, picked by hired labor, he netted only 20½ cents a box. The consumer pickers were able to save several cents a box on what local stores would have charged for the fruit.

Maintenance of Meadow Yields

MOST Ohio meadows are grown in rotation and are kept down for 1 to 3 years. The problem which farmers face, therefore, is to adopt fertility practices which insure that meadow yields will be as large or larger 10 or 20 years from now as they are now.

High yields and sometimes almost spectacular yields are more likely to occur in second- and third-year meadows rather than in the first year of cutting. This is made possible by the fact that the perennial plants such as alfalfa, ladino, timothy, and bromegrass, when given a fair chance, continue to develop throughout the first hay year into bigger and more deeply rooted plants. At the beginning of the second hay year, plant conditions are favorable for maximum utilization of sunshine, rain, and available soil nutrients.

At the Experiment Station it has been rather common to have second- and third-year meadows yield one-half more than first-year meadows. This is on the basis of about 3 tons of hay per acre for first-year meadows and 4½ tons or slightly more for the following year or two. Individual years have exceeded 5 tons per acre. Yields this large are presented as practical goals.

Many people do not have a clear realization of what is required to keep meadow yields reasonably high rotation after rotation. It sometimes seems as though nature can be deceptively subtle and an all too common occasion for this subtlety is when individuals make their first real attempt at grassland culture. Results quite often are meadows in all the abundance that these individuals have been led to expect. Perhaps, it is only logical that many should get the erroneous idea that meadow production is extremely easy and not many problems are involved.

Consider, for instance, the farmers in the hill section of Ohio who trash-

mulched the depleted hillsides and treated them with moderate amounts of limestone and fertilizer. In less than 12 months they were cutting hay yielding more than they previously had considered possible. Or, take the case of the old dairy farms of northeastern Ohio which had deteriorated to the timothy and soybean hay level. Four, six, or eight tons of limestone per acre and an alfalfa-ladino-timothy combination, in the short space of a year or two, changed farm conditions from half-filled hay mows to those that were running over into stacks on the outside.

It is no wonder that these success experiences created a feeling of meadow security which had very little room for any serious doubts about the future. Wasn't grass good for the land? Didn't grass rest the land? These and other similar ideas lulled many individuals into a false sense of security.

Fortunately, the failures were more than balanced by the successes. Evidence piled up regarding proper soil treatment for continued meadow success. Nature created soils in such a manner that any decline in productive level is very gradual and with no early, easily detected signs. So when the once highly successful fields were reseeded a rotation or two later and the results were not so pleasing, there was a tendency to put the blame on the weather or something other than soil depletion which probably was the real reason.

Limestone, phosphoric acid, and potash all have an influence on the maintenance of high meadow yields. Where unsatisfactory yields tend to occur after one or more rotation, trouble often can be traced to potash depletion rather than any deficiency of lime or phosphoric acid.

It still is not sufficiently understood by many farmers that big hay crops may take from 3 to 5 times as much potash from the soil as former grain crops have been taking. Potash conservation is more necessary under grassland farming than for grain culture. . . . *M. A. Bachtell, Agronomy Department, Ohio Agricultural Experiment Station, Wooster, Ohio.*

Five—acre Cotton King . . .

(*From page* 17)

Shortly after the cotton was thinned, Mr. Smith made a side application of 200 pounds of 50% muriate of potash and 50 pounds of ammonium nitrate per acre. With good weather, his cotton grew off nicely, began to fruit rather early, and there was no evidence of the plants growing too large.

A full and complete program of boll-weevil control was carried out. When the first squares began to appear, an application of 1-1-1 molasses arsenic mixture was applied. A second application of the same material was applied 10 days later. Then around June 10 he began to apply about 10 pounds per acre of 3-5-40 BHC. This process was repeated at one-week intervals until four applications had been made by ground. One dusting was made by airplane on August 10, with 15 pounds of this same dust.

It is very interesting to note the great similarity between the way the field of J. Harvey Neeley of Chester County, previous record holder with 8,275 pounds of lint cotton in 1949, and Mr. Smith's field were fertilized. Total plant food applied to Mr. Smith's field was about 50 pounds (N), 135 pounds (P_2O_5), and 235 pounds (K_2O). Even on a fine type of soil like Marlboro, you can see that a large quantity of potash was used to grow cotton advantageously. Mr. Neeley, on his field, used a substantially large amount of potash per acre like Mr. Smith did.

In 1951, Mr. Smith had on his home place, a total of 46 acres of cotton. Other than the contest field, the cotton was planted in 36-inch rows. On 46 acres he produced 96 bales of cotton.

As a result of the lessons learned by the farmers themselves and given to all the other cotton growers by the annual contest report, there was produced by them in South Carolina the outstanding crop of all time as to yield per acre, uniformity of staple, and spinning quality. The farmers have found from the contest not only best cultural practices, but the variety to plant. This has contributed in a large way to maximum yields of uniformly fibered, high-spinning-quality cotton. In 1951, about 70% of the cotton produced was in one length only, that being 1 1/32 inches. One variety production in large areas gives the spinners large quantities of high-quality, uniform-spinning-quality cotton.

Virginia Revises . . .

(*From page* 22)

was agreed that the law should be revised in order to meet present conditions.

Representatives of the State Farm Bureau Federation, State Grange, and the Agricultural Conference Board, made up of some 60 organized farm groups in Virginia, were consulted and a tentative draft of a new fertilizer law was drawn up. Copies of this tentative draft were sent to all fertilizer manufacturers doing business in Virginia. All interested groups were invited to attend a public discussion of this draft in the Senate Chamber of the State Capitol on December 17, 1951. The draft was considered section by section and a number of changes were made. With the incorporation of the changes, there was practically unanimous approval by all interested parties. After review by the Legislative Drafting Bureau, the bill was introduced as Senate Bill No. 270.

The bill as presented had the full endorsement of the Department of Agriculture, the Experiment Station and Extension Department of V.P.I., the Virginia Truck Experiment Station, the Agricultural Conference Board, the Virginia Farm Bureau, the State Grange, and the Fertilizer Manufacturers doing business in Virginia. No voice was raised against the bill and it passed with the unanimous vote of the General Assembly and was signed by the Governor on March 11, 1952.

This new fertilizer law does not change the fundamental principles of the present law which have proved satisfactory in the control of the sale of fertilizers for over 50 years. It provides full protection to the purchaser, fair competition in the sale of fertilizer to meet the needs of the Virginia farmer, and eliminates some of the obstacles encountered in the movement of fertilizer in interstate traffic, particularly between Virginia and North Carolina.

The new law establishes definitions of terms, provides for uniform labeling, and removes the limit on the number of grades which may be established by the Grade Committee. It will go into effect July 1, 1952.

The old law did not permit the sale of ground rock phosphate. The new law will permit the sale and use of ground rock phosphate when properly labeled to protect the purchaser. With the present shortage of sulphur which is used in the manufacture of superphosphate, it appears desirable that ground rock phosphate be made available for use as recommended by the Virginia Experiment Station.

The enforcement of the Virginia Fer-

tilizer Law is under the direction of Rodney C. Berry, State Chemist and Director of the Division of Chemistry. Records over the years show that Virginia farmers have been fully protected through rigid enforcement of fertilizer laws, and the cooperative support by the manufacturers indicates confidence in the impartial performance of duties by Virginia Control Officials.

Why Plants Differ . . .

(*From page* 16)

of potassium produced a violent mass action or crowding of potassium into the plant producing unbalanced or so-called "luxury consumption" of potassium.

Practical applications of fundamental information. Here are some points to consider in choosing a grain nurse crop for legume or legume grass seedlings. The cation exchange capacity of the roots is more than twice as great for oats as for wheat. Thus oats roots will take in more calcium and magnesium than wheat, but wheat roots will take in more potassium than oats. As a nurse crop for legume seedlings, wheat would offer less competition for calcium and magnesium than oats, but oats would offer less competition for potassium than wheat. Thus one would reason that as a nurse crop for legume seedlings, oats would be better than wheat on a high lime-low potassium soil, but wheat better than oats on a high potassium-low lime soil.

Roots of associated grass and legume compete for cations. When two different plants, as a legume and a grass, are grown together, the root colloids of the legume and the grass compete for potassium, calcium, cobalt, and magnesium. Let us consider a mixture of alfalfa and the hay grasses, timothy, red top, bluegrass, and bent grass. Unless the soil is well supplied with available potassium or liberal applications of potash fertilizer are supplied, the alfalfa often fails to produce satisfactory yields after 1 or 2 years; however, the companion grasses, such as timothy, red top, bluegrass, and bent grass, may continue to grow for many years with a relatively low level of available soil potassium. Many experiments have demonstrated that with adequate amounts of available soil or fertilizer potash the valuable legumes alfalfa and ladino clover may continue to grow and to produce large yields of forage for many years. We believe the failure of the legumes was due to their inability to compete with the companion grasses for essential potassium, at low levels of available soil potassium.

Availability of soil potassium drops during growing season. Because of uptake and removal of potassium by the growing plants, the amount of available or exchangeable potassium decreases in many soils as the growing season progresses. Field experiments confirm our theory that the competition between grasses and legumes for potassium increases and becomes more critical as the growing season advances. The potash efficiency of the grass compared to the legume is much like comparing the efficiency of a modern vacuum cleaner to the old carpet sweeper. That is, potassium uptake becomes increasingly more difficult for the legume as the level of available or exchangeable soil potassium declines. One might compare the legume root to a six-tined manure fork, the grass root to a scoop shovel, and the potassium to corn. Let us imagine that the available or exchangeable potash is ear corn and that the difficultly available or nonexchangeable potassium is corn kernels that have been shattered

from the ear. As long as there are many whole ears, the six-tined fork can pick up many ears of corn. When only shelled corn remains, it is very difficult to pick it up with a fork, but a scoop is still effective.

Efficiency of timothy compared to alfalfa at low levels of soil potassium. The relative abilities of timothy and alfalfa to obtain difficultly available potassium were compared by growing these plants in greenhouse pots on a soil low in available potassium. Timothy removed three times as much potassium as was measured as available (exchangeable plus soil solution). In contrast, alfalfa grown on the same amount of soil and during the same period removed less than the available amount of potassium. Actually the total growth of alfalfa hay contained only ¼ as much potassium as the timothy. If 10 successive crops of timothy and alfalfa had been grown, the relative potash removed by timothy would have been much greater.

Why can many grasses grow on a soil very low in available potassium? There is a balance in the soil between available and unavailable potassium. As the available potassium is removed by roots of growing plants, some of the unavailable potassium slowly shifts to the available form, thereby supplying a low but relatively constant supply of available potassium. For certain plant species, such as timothy, red top, and bent grass, with low exchange roots, this low level of available potassium is adequate to maintain growth. The lower exchange roots of certain grasses therefore more completely remove the available potassium. This more complete removal of available potassium in turn increases the rate and amount of potassium which slowly changes from the nonexchangeable or difficultly available to the available form. Thus on soils low in available potassium, timothy and other grasses "unlock" or increase the rate of release of mineral reserves of soil potassium.

How do we reduce the competitive advantage of grasses for potassium? The answer—by frequent, liberal topdress applications of potash fertilizer, by using more compatible grasses in grass-legume mixtures, and by special management to favor the legume but to handicap the grass. Early mowing for grass silage, or early and rotation grazing, favors the legumes, handicaps the grass, and thus reduces the grass competition for potassium. As stated before, because the legume roots take up relatively more calcium and magnesium than potassium, the legume often has great difficulty obtaining enough potassium. If large amounts of soil or fertilizer potassium are available, by mass action sufficient amounts of potassium crowd into the plant root.

Importance of frequent topdress applications of potash for legumes. We must recognize that large single applications of potash fertilizers will cause violent mass action or "luxury consumption" of potassium. Unbalanced or "luxury consumption" means

TABLE II.—POTASSIUM UPTAKE BY PLANTS FROM GREENHOUSE POTS OF SOIL CONTAINING EIGHT LEVELS OF POTASSIUM (EXCHANGEABLE K PLUS SEVEN INCREMENTS OF KCl)

K_2O contents of soil and plants in grams per pot

K_2O content of soils*	K_2O content of plants (Roots excluded)		
	Oats	Barley	Wheat
0.267	0.15	0.24	0.42
0.567	0.33	0.36	0.50
0.867	0.50	0.56	0.77
1.167	0.81	0.81	1.09
1.467	1.12	0.96	1.02
1.767	1.35	1.24	1.37
2.517	1.70	1.56	1.83
3.267	2.04	2.05	1.88

*6 Kgm. soil per pot.

that the plants are abnormally high in potassium, which (1) wastes potassium and (2) lowers the calcium and magnesium content of the forage. For example, if the 100 to 200 or more pounds of fertilizer K_2O needed annually on many of our soils for satisfactory growth of ladino-brome are applied in the spring or late fall, the potassium content of the forage is often increased 50 to 100 per cent in the first cutting. This high uptake of potassium in the first cutting often results in a deficiency for potassium in the second or third cuttings. The fundamental reason for frequent summer topdressings of legume-grass pasture and haylands with potash fertilizer is to (1) supply potash in a form and in amounts that will satisfy the needs of the legume throughout the entire growing season and (2) to prevent "luxury or unbalanced consumption" of potassium.

Reduce potassium competition by selection of companion grasses. The more nearly equal the cation exchange capacities of the grass and companion legumes, the more compatible the two plants should be in uptake of mineral nutrients. Grass competition for potash should increase as the cation-exchange capacity of the plant root decreases. Reed canary grass or alta tall fescue should be the most compatible companion grass—potash wise—for alfalfa or ladino clover, with orchard grass or smooth brome also highly compatible, timothy and bluegrass less, and red top and bent grass least compatible (Table I). Under field conditions, the relative compatibility of these grasses may be in a slightly different order than the root exchange values, since the root systems vary and the rate and period of growth are differently affected by light, moisture, fertility, and soil temperature. Field plot tests indicate that smooth brome grass is one of the most compatible grasses for either ladino clover or alfalfa, orchard grass is next, and Kentucky bluegrass, red top, and bent grass are the least compatible—Kentucky bluegrass almost invariably replaces all other grass species at moderate fertility levels in New England pastures and meadows. Bent grass has a lower cation exchange root system than bluegrass and replaces Kentucky bluegrass at low fertility levels.

Shall we fit the soil to the plant or the plant to the soil? A system of farming that will "unlock" our tremendous reserves of potassium minerals in the soil has a popular appeal. However, such a system in Massachusetts eliminates the use of legumes because to "unlock" soil mineral potassium effectively, the level of available or exchangeable potassium must be very low—too low to grow legumes. Such a system of farming must be geared to the growing of such low-quality forage plants as red top, bluegrass, and bent grass and means that the entire cropping system and standard of animal nutrition are limited to a substandard level. What modern dairy farmer can afford to operate under these conditions?

Are there practical uses for cation exchange values of other crop plants? Yes, the root exchange values help explain nutrient requirements as well as mineral content of many other crops. For example high-potash fertilizers are required for maximum potato yields especially on soils low in available potassium. The combination of a limited root system, high cation exchange, capacity of these roots (Table I), and the large amounts of potassium required in the potato plant to translocate sugars and store starch explains why it is necessary to supply much more available potassium than is actually taken into the potato plant. In general, this same principle applies to tomato, tobacco, peas, beans, and many other plants with limited root systems but with high cation exchange roots.

Weeds are serious competitors to crop plants for minerals. The high cation exchange capacity of the dicot weeds shows why these plants are seri-

ous competitors of agricultural plants, especially for exchangeable calcium and magnesium. Ragweed is common in grain stubble and competes seriously with clover seedlings for cations as well as light and moisture. Likewise, the prevalence of pigweed in soybeans, truck crops, and in temporary summer pastures presents a serious problem in mineral competition. Yellow foxtail is a common weed grass during late summer in grain stubble, hay fields, and pastures. Foxtail roots were extremely low in exchange capacity. At low levels of soil potassium, such weed grasses in both cultivated and sod crops are serious competitors for available potassium.

Summary. The mineral composition of plants is largely determined by physical-chemical relations between the colloidal systems of both the plant root and the soil. Plant material of legumes, and many other dicotyledonous plants, contains relatively larger amounts of calcium and magnesium than grasses and other monocotyledonous plant material, not because these dicot plants require larger amounts of calcium and magnesium within the plant, but because the nature of the root colloid forces large amounts of calcium and magnesium into these plants. Legume and many other dicots with roots of high cation exchange capacity must be liberally fertilized with potassium, not because these plants have a higher potassium requirement, but because the nature of their root colloid is such as to require a high concentration of available potassium in the soil to overcome the valence effect (Donnan equilibrium), thereby crowding potassium into the root by mass action, and thus supplying the legume with sufficient potassium for normal growth. These fundamental relationships have a profound influence on the selection, fertilization, and cultural management of all crop plants.

Terrebonne Clay Loam . . .

(*From page* 21)

soil to stimulate vegetative development, the plant's requirements for readily available potassium are amplified, and if the plant does not find in its immediate environment the necessary amounts of potash to balance the uptake of other nutrients, either delay in maturation or reduced yields are to be expected. These views are also held by G. E. Smith [3] concerning U. S. Midwestern soils where the average analysis of all fertilizer materials used in Missouri was 4.83% potash in 1941 and 8.76% potash in 1951.

Another point of major importance is the growth stage at which potassium is available. The better results obtained with early fertilization of pastures and meadows are corroborative examples. The plant that gets a good start does better later on. If, for some reason, potassium is insufficient to meet the plant's needs when it is in active development (early growth stage), subsequent larger amounts of disposable potash will not adequately compensate. This agrees with F. E. Bear's [1] recent article "Soil Fertility and Pastures" in which he states that "in a 5-year test of nitrate of soda and sulfate of ammonia on permanent pastures at New Brunswick, the yields were 36% greater on the average from March applications than from those in October. In similar comparisons of a phosphate-potash mixture, the yields were 22% higher from the March applications."

An important characteristic of chemical tests (Morgan, Thornton, Spurway) for available potassium in these plots, and also for exchangeable potassium (normal neutral ammonium acetate),

was that, both years, no significant correlation could be found between them and yields either before or after the crops; the check plots, with the lowest yields, gave tests not too different from the plots with the higher yields. This is apparently due to the fact that potassium is slowly fixed by the colloidal complex in non-available form. It might explain why potassium in this soil seems to be available in sufficient amounts in the course of a growing season when moderate quantities of complete low-potash fertilizers are used; but when larger amounts of complete low-potash fertilizers are applied, the soil potassium does not become available rapidly enough to compensate. Consequently, the yields are improved when a more substantial quantity of readily available potash is at the plant's disposal in the early stages of the growth cycle.

Summary

Despite their high total potash content (2-3%), some of the heavier soils in the Montreal region, when receiving larger fertilizer applications, have been noticed to bear plants exhibiting slight potash deficiency symptoms. The fertilizers generally applied were those recommended for such soils, i.e., fertilizers containing a minimum percentage of potash (2-12-6, 2-16-6, 4-12-6) as compared to those recommended for lighter soils. It was, therefore, presumed that such soils did not receive an adequate amount of potash to meet the growing plant's requirements. In order to investigate the possibility of potash being a limiting factor, experimental plots were set up in 1950 and 1951 for such crops as hay, oats, sweet peppers, tomatoes, and onions.

The soil used in these experiments is classified as a Terrebonne clay loam and is rated fertile. The treatments consisted of a check application of 4-12-6 as compared to 4-12-8, 4-12-10, and 4-12-12, all at equal rates of application for a given crop. An additional treatment for each given crop consisted of a larger application of the 4-12-6 check application.

Plot yields for both years indicate a response of the crops to the additional potash in the fertilizer. Applied in equal amounts, 4-12-6 and 4-12-8 gave similar yields for all crops, while 4-12-10 and more often 4-12-12 gave maximum yields. In most cases, 4-12-10 at a given rate of application gave yields similar to those obtained with 4-12-6 applied in excess of that rate. Applied to onions, 4-12-12 in addition to producing maximum yields has also hastened maturation of the plants.

Analytical data lead to the belief that potassium in this soil, although abundant in total quantity and fairly abundant in exchangeable form, may be too slowly available to a rapidly growing plant. This, apparently, is due to slow fixation of potash by the colloidal complex in non-available form. The experimental results may explain why potassium in this soil seems to be available in sufficient amounts in the course of a growing season when moderate quantities of complete low-potash fertilizers are used, but when larger amounts of complete low-potash fertilizers are applied the soil potassium does not become available rapidly enough to compensate. With the actual trend of increasing rates of fertilizer applications, this lack of readily available potash may become more pronounced. As more nitrogen and phosphorus are added to the soil to stimulate vegetative development, the plant's requirements for potassium are necessarily amplified.

References

1. Bear, F. E. 1951. Soil fertility and pastures. Better Crops With Plant Food. December.
2. Robertson, W. K. and DeLong, W. A. 1947. The potassium status of Eastern Canadian soils. Proc. Soil Sci. Soc. Amer., 12:163-166.
3. Smith, G. E. 1952. Potash needs move West. Better Crops With Plant Food. February.

Potassium-nitrogen Balance . . .

(*From page* 12)

trates root conditions found at the Oblong Field in 1950. These different root conditions help to explain the types of stalk lodging seen under various soil conditions.

Why does corn lodge more with low-potash and high-nitrogen conditions? Roots from lime-phosphate plots from Oblong, Newton, and Toledo Fields showed a tendency to rot prematurely. Such roots are somewhat stunted and many are brown. Close examination of individual lodged stalks show either weak root anchorage due to weak, rotted roots, or stalk breakage near lower nodes. If you cut open broken stalks of this type, the nodal tissues are found decomposed. We know that earlier in the season such nodes were abnormal with darkened areas and deposits of iron clogging the conducting tissues at the nodes. A chaffy ear probably will be found on such stalks because it could not fill normally. A normal plant will mature an ear on a green stalk while the roots are still active. Stalks on the RLPK plots had more fibrous roots which did not decompose prematurely.

Similar root conditions were found in one-year trials with fertilizers. Figure 6 illustrates typical roots and ears from potash-starved and normal plants well fertilized with 3-9-27.

Lodging Reduced

Corn stalks may lean or break from causes other than potassium deficiency, such as, high water table, late planting, thick stands, varietal differences, diseases and insects. On unlimed plots with potash, at Newton and Oblong, lodged stalks are seen even with small stunted plants. When roots of such plants are examined, they are very much stunted, although still functioning under a green stalk. (See root at right, Fig. 1.) Restricted root growth for any reason reduces root anchorage. Insects such as corn root worms may cut off roots. Corn borers weaken stalks so they break. Diseases sometimes attack corn with supposedly adequate potassium. Chinch bugs seem to like potash-starved corn, and potash starvation symptoms have been mistaken for chinch bug damage.

The point is that lodged corn is not a sure sign of potash starvation, but if the corn is potash-starved and has plenty of nitrogen, it is most likely to lodge. Figure 7 shows severe lodging on the 4-16-0 plot with nitrogen in the 1950 Adams trials.

Nutrient Balance Necessary

The interdependence of nitrogen and potash was demonstrated again in the farm trials (Tables III and IV) with the same relationship as noted in Oblong Field data (Table I). Increases from nitrogen alone, or potash alone, usually are less than when one nutrient is combined with the other. Note upward yield trends (column 3, Table

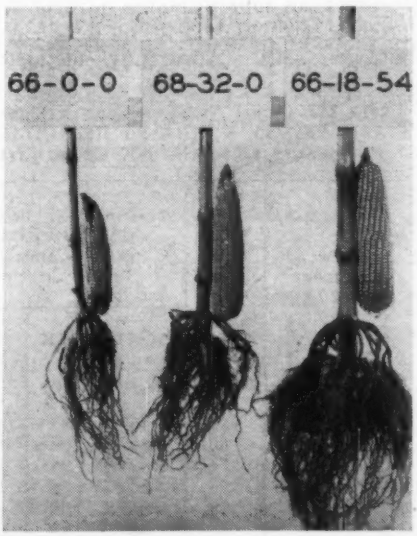


Fig. 6. Adequate and balanced nutrition produced more and healthier roots. Figures refer to total pounds of N, P_2O_5, and K_2O applied. George Deatherage Farm, Oblong, Ill., October, 20, 1951.

III), showing expected responses from increasing amounts of potash when nitrogen also is added. The same trends are shown in column 3, Table IV from 1950 farm trials. *The greatest response to nitrogen came when high-potash fertilizers were used in the row or heavy potash applications broadcast. Conversely, potash benefits were relatively larger when more nitrogen was present.*

Table IV shows fertilizer responses on two low-nitrogen fields. (See Table II for soil tests, etc.) All fertilized plots reached a common yield level when nitrogen was low, with a top of only 42 bushels. With proper combinations of treatments the yields were doubled, and increases from row fertilizers correlated with their potash contents.

Nitrogen Responses Variable

Amounts of legume hay residues left to plow under for corn seemed to determine increases for sidedressed nitrogen, both on farms and at Oblong Field in 1951. (See Table V.) When properly managed, red clover and other legumes can supply enough nitrogen to produce fairly high yields on these low-nitrogen soils. Apparently adequate nitrogen for a 105-bushel yield level was available on the Oblong RLPK plot, where there had been an excellent stand of legumes in mixed hay and only one hay crop was removed.

Poor clover stands or excessive hay removals resulted in too little available nitrogen on some farms. It appears that corn following only fair stands of red clover had only enough nitrogen for 65 to 70 bushels of corn. When mineral nitrogen supplemented clover nitrogen in the latter fields, no nitrogen starvation symptoms were seen in August, and yields were increased as much as 30 bushels.

Fairly adequate railfall during critical midseason growth, both in 1950 and 1951, probably increased relative responses to nitrogen as well as assured higher maximum yields.

Phosphorus Benefits

Increases from phosphorus in mixed fertilizers seemed quite variable in farm trials, and were estimated at about 2 to 10 bushels per acre on soils testing "low" in available phosphates.

Average 4-year increases of corn from phosphorus on experiment fields are as follows: Oblong, 8 bushels; Toledo, 10 bu.; and Ewing, 11 bu. These are

TABLE III.—1951 AVERAGE CORN YIELDS FROM THREE FARMS, (DEATHERAGE, METTE, AND ADAMS) FOLLOWING RED CLOVER, WITH INCREASES FROM NITROGEN (N), POTASSIUM (K), AND NK COMBINATIONS.

Row treatment (200#/A)	Yields with row fert. alone	Yields with extra N and K			Incr. from NK	Increases from nitrogen		Increases from potash	
		+N	+NK	+K		from N alone	from NK/K	from K alone	from NK/N
	Bu.								
No fertilizer	35	45	89	73	54	10	16	38	44
4–16–0	59	64	100	70	41	5	30	11	36
2–12–6	74	83	94	72	20	9	22	−2	11
10–10–10	76	86	95	75	19	10	20	−1	9
3–12–12	73	85	98	81	25	12	17	8	13
3–9–18	78	95	95	77	17	17	18	−1	0
3–9–27	78	97	94	79	16	19	15	1	−3

N—60 lbs. N sidedressed.
K—180 to 225 lbs. K_2O broadcast after plowing.

TABLE IV.—AVERAGE CORN YIELDS ON LOW-NITROGEN SOILS, BOGGS AND ADAMS FARMS, 1950.

Starter fertilizer 200# /A in row	Average corn yields—Bu. per acre		
	Starter fertilizer only	Plus 60 lbs. N	Plus 60 lbs. N and 120 lbs. K_2O
	Bu.	*Bu.*	*Bu.*
None	37	42	80
2–12–6	38	67	83
3–12–12	36	70	82
3–9–18	41	74	84
0–9–27	42	79	81

N—sidedressed at second cultivation.
K_2O—200 lbs. 0-0-60 broadcast after plowing and disced in.

long-time effects, both direct and indirect.

Corn Quality Improved

Chaffy ears of corn were commonly found where potash levels were low and nitrogen adequate. Barren-tipped nubbins with shallow kernels were plentiful where corn ran out of nitrogen before maturity. Balanced nitrogen-potash relationships produced excellent quality corn in all experiments.

Summary

1. All starter fertilizers were less effective when soil nitrogen was low.

2. On low-potash soils, yields increased in direct relation to amounts of potash supplied by starter fertilizers when used with nitrogen.

3. Muriate of potash alone gave close to peak yields on Deatherage farm, which had been limed, phosphated, and grown clovers.

4. Responses to sidedressed nitrogen were closely related to previous hay removals.

5. Stalk lodging on low-potash soils was reduced by applying enough potash to balance the available nitrogen.

TABLE V.—NITROGEN RESPONSES RELATED TO GROWTH AND MANAGEMENT OF PREVIOUS LEGUME CROPS

Location, legume, and management	Final stalk population per acre	Corn yields per acre extra K	Increases for 60 lbs. N (NK/K)
Adams farm, poor stand red clover; all hay removed	9,070	65*	30
Mette farm, good stand red clover; all hay removed	8,450	73*	18
Deatherage farm, good red clover; 1 hay crop removed, seed combined	9,320	90*	6
Yaw farm, Excellent' 1-year sweet clover; plowed down green	11,100	103*	13
Oblong S. E. F., RLPK plot, 1 mixed hay crop removed	11,500	105	3

*Averages of all fertilized plots with extra potash (K).

Fig. 7. Only 36 pounds K_2O per acre in 200 pounds of 3-9-18 made this difference in growth and lodging. Both plots were sidedressed with 60 pounds N. Yields, 82 and 54 bushels. Stanley Adams Farm, Teutopolis, Ill., September 29, 1950.

6. Total root growth and condition are improved by proper soil treatments.

7. High-potash fertilizers retarded severe leaf breakdown in certain fields, September 1951.

8. Phosphorus in mixed fertilizers gave increases on low-phosphorus soils.

9. Fertility needs may be expected to change gradually as a soil improvement program progresses. After corrective applications of limestone, phosphates, and potash have been made, growers should keep a close watch on the fertility balance by field observations, tissue tests, and soil tests. Nutrient balance can be maintained by starter fertilizers and supplementary treatments.

Concerning H_2O . . .

(*From page* 5)

Irrigation brings up a watery subject too. To many vehement folks I have met, irrigation spells irritation. Sometimes the guy's right on the irrigated project are also irritated, but this is not what we wish to convey. We are familiar with the major irrigation enterprises west of the 97th meridian. We know about the latest and biggest venture, that of the Grand Coulee Dam. Interior Department engineers have put in 12 electric pumps, each of which has enough water-lifting power to take care of the whole City of New York, ready to push water behind the huge dam through 4,500 miles of laterals and main ditches to the dry-land plantations staked out by veterans.

But now we enter an era when irrigation, or artificial watering, is being rapidly installed in the so-called humid regions, which mostly lie east of the 97th meridian and in the western parts of Oregon and Washington. The theory which led to this expansion of

humid area irrigation is that often critical periods occur during which soil moisture is not sufficient for optimum plant growth and maturing. I am not sure whether all the out-and-out soil conservation engineers are sold on irrigation systems, or if they believe that land management methods of themselves will do enough to maintain ample soil moisture reserves. Anyhow, it's here and we might as well take a look at it.

LOTS of us are familiar with the marshy conditions under which for years on end men have found it pays to grow rice, watercress, and juicy cranberries. Here control of the water levels has been one of the tricks of the trade. Now engineers and manufacturers are busy working on overhead sprinkler systems with adjustable nozzles and electric starters and stoppers galore. Nearly half of the 800,000 acres under artificial moisture operations in the humid zones of the country had these sprinklers going under a schedule that must be carefully planned and based on studies of water levels and available soil moisture. Back 10 years ago, less than 300,000 acres were irrigated in the "rainy" belts of the nation.

Early research by soils men and farm engineers looking toward a dependable emergency water supply for valuable cash crops began in New Jersey, Florida, and Wisconsin—some of it as far back as 1900. I can recall visiting a pioneer irrigator with a home-made sprinkler system that watered about 25 acres of light sandy soil in Marquette County, Wis. He was thus able to grow and deliver truckloads of fresh cantaloupes and cucumbers, watermelons and cabbage to a whole chain of towns and villages during the driest spells ever experienced.

Florida seems to have had the enterprise to get a head start in the crop-sprinkling business. They tell me that supplemental water is being put on vegetables, citrus, and flowers mainly in Florida in an area of about 350,000 acres—better than 40 per cent of all the country's humid area irrigation. Other states lying within the normally damp sections where substantial acreages are irrigated include 155,000 acres in California, Oregon, and Washington; 26,275 acres in New Jersey; nearly 14,000 acres in Michigan; close to 10,000 in Wisconsin; 16,700 acres in Massachusetts; Connecticut with over 8,000 acres; and South Carolina's 6,500 acres or more.

By regions, the Northeast states have about 61,000 acres with 41,000 using sprinklers; the Southeastern about 368,000 acres, possibly half with sprinklers; the Northcentral Region, some 31,000 acres, two-thirds using sprinklers; the Southwest region, about 133,000 acres; Kansas and Nebraska together about 3,000 acres; and the Pacific states 155,000 acres, of which about 104,000 use sprinklers instead of the usual gravity and ditch system.

Aside from the practical help readily given to farmers by irrigation supply companies, most of the technical assistance that has been on tap in this line comes from the U. S. Soil Conservation Service. It is reported that during 1951, the SCS engineers advised and helped owners to install nearly 40,000 acres of new irrigation systems in the humid regions. A long list of current research projects now being conducted in 15 states and Puerto Rico are intended to overcome many of the rule-of-thumb and haphazard operating programs that always bob up in any untried field of engineering. Humid area irrigation really has its headaches and pitfalls, its booby traps and frustrations.

You can't blunder along and guess at certain things men must really know before spending good cash on irrigation. Too many have, however. What is the greatest amount of water that various crops really need? What is the best time, and the right quantity to use? Is the land of proper texture or will too much artificial water puddle and bake it hard? Should we know

the exact water-holding capacity of the land, or just keep on squirting and trust to Lady Luck to bale us out?

Folks have also found that fertilizer can be wasted, some soils waterlogged, alkali deposits increased, and erosion started if the wrong nozzles are used or the wrong pressure is applied—or if a farm gets a dashing rain too soon after the sprinklers have been turned off. So it's a task for trained men, for education and careful instruction to the farm-owner—which is just the same rule that governs any device newly adopted.

Whether to install surface and channel irrigation or use the sprinklers is also largely a matter of the topography of the farm, specialists say. Some land can be leveled up for surface watering in the western style, but extremely rolling areas lend themselves much better to overhead "shower" applications.

It appears also that state laws in respect to water-using rights and privileges will always be a factor in securing stability for any humid region irrigation plan. Thus we run afoul of lawyers and permits and such rather bothersome but necessary details. Over in the eastern seaboard states the old common law of riparian rights usually prevails. That is, only owners of lands riparian to a stream of water may make reasonable use of water lifted out for irrigation—and then only on his riparian, or stream-bordering, land.

So far few cases have been brought into court involving such water usage for irrigation, but as the systems increase there is bound to be agitation over removal of water from streams in large volume. We are also reminded that the advisable method for extensive new projects in this watering business must consider development of a community-type water system, maybe in connection with those proposed huge storage reservoirs which may be designed for flood control or power facilities.

Perhaps in a dozen years, if prices of farm products warrant it, there will be a great increase in these artificial rain-making outfits. It might allow the use of the improved plant species and pasture-seeding mixtures which will play their part in higher yields as well as in stopping gully washing.

IT is almost certain that the extra expense entailed in the design and installation of a good irrigation system in the humid areas will call for intensive farming practices to make the crops bigger and more profitable. Such practices could lead to more grass for livestock and better rotations, as well as maintaining high levels of fertility.

And after all is said and done, it's just as important for us to check the loss of water from the cracked and sticky, hard-pan soils and the thin, weak sands minus organic matter as it is to spend time and money to dash more H_2O on our acreage. Just pumping up water from convenient places and dumping it on any old kind of exploited cropping venture is neither sane nor scientific.

Yes, we have come to a time when even water is precious. Our hatred for it in boyhood neck-bathing days is forgotten. We have grown up to learn that saving water by the wiser use of it is a science which farmers can test themselves. All our schemes for bigger food goals and bumper harvests go glimmering when rains fail us and the dry seasons blast our hopes.

When we witness crop loss by flood and by drouth in the same month, we begin to soften our attitude toward interstate and even federal cooperation to gain security for ourselves and our units of production. Your good old well-dowser is good enough in his way, and the rivulet in your meadow is nice to look at, but in the future a planned system of water use and conservation is the only thing that will save us from hazard, loss, and recurring disappointment.

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IMPORTANT

Requests should be made *well in advance* and should include information as to group before which the film is to be shown, date of exhibition (alternative dates if possible), and period of loan.

Request bookings from your nearest distributor.

One evening a young matron, returning from a First Aid meeting, came upon a man sprawled face down on a darkened side street. Parking her car nearby, she rushed over and began artificial respiration. Presently the man stirred, looked up, and speaking with difficulty, said: "I'm holding a lantern for a guy working down in this manhole. I ain't sure what you're up to, lady, but this ain't the time or the place."

* * *

Hoping to get a rise out of the farmer hoeing in a field, a city smarty called: "Hey, Rube, did you see a wagonload of monkeys go by here?"

"No," replied the farmer, "did you fall off?"

* * *

Lady: "I'm afraid I'll have to return that parrot I bought here some time ago. He shocks all my friends by his dreadful language."

Dealer: "Ah, you've got to be careful 'ow you talk before 'im Lady. 'E's terrible quick to learn."

* * *

G. I. Guy: "Do you ever expect to find the perfect girl?"

Joe: "No, but it's sure a lot of fun finding out they're not."

* * *

"Did you get home all right from the party last night?"

"No trouble at all, except that just as I was turning into my street some fool stepped on my fingers."

"They tell me in Mexico you can get three pounds of sugar, a pound of coffee, a quart of whiskey, and a wife for three dollars."

"I'll bet it's rotten whiskey."

* * *

Kissing is just so much chemistry. It has to do with a craving for salt. The history of a kiss goes like this:

The cave man found that salt helped cool him off in the summer heat. He found that he could get salt by licking his neighbor's cheek.

It was discovered that the process was more interesting if the neighbor was of the opposite sex.

Then everybody forgot about salt.

* * *

He: "Please."
She: "No!"
He: "Oh! Please."
She: "No!"
He: "Just this once."
She: "I said, no!"
He: "Aw, Mom, all the kids are going barefoot."

* * *

"Now gentlemen," said the president of the Sugar Baby Bottle Co., "we have 25,000 of these feeding bottles in stock, and the company expects you salesmen to go out and create the demand."

* * *

"And so you're ninety-nine! Well, I sure hope I can get back next year and see you a hundred."

"Can't see any reason why not, young man. You look healthy enough to me."

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• Agricultural authorities agree that boron is an essential plant food just as are nitrogen, potash and others. A boron deficiency in soil causes dwindling crops and puny plants... but borax restores lost boron. Users of our fertilizer borates* report increased yields of alfalfa, pasture crops and many vegetable, field and fruit crops, plus greatly improved quality.

* **FERTILIZER BORATE** (*equivalent to approximately 93% borax*) and **FERTILIZER BORATE—HIGH GRADE** (*equivalent to approximately 121% borax*) offer you low-cost, economical sources of boron... in fine mesh for addition to mixed fertilizer, or coarse mesh for direct application where required. County Agents or State Experimental Stations should be consulted for detailed recommendations. Write today for literature and quotations.

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The following literature on the use of fertilizers in profitable soil and crop management is available for distribution. We shall be glad to send these upon request and in reasonable amounts as long as our supply lasts.

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Asparagus (General)
Vine Crops (General)
Better Corn (Midwest)
The Cow and Her Pasture (General)

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J-2-43 Maintaining Fertility When Growing Peanuts
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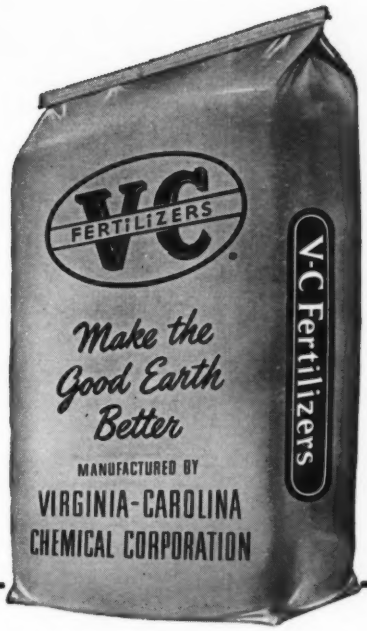

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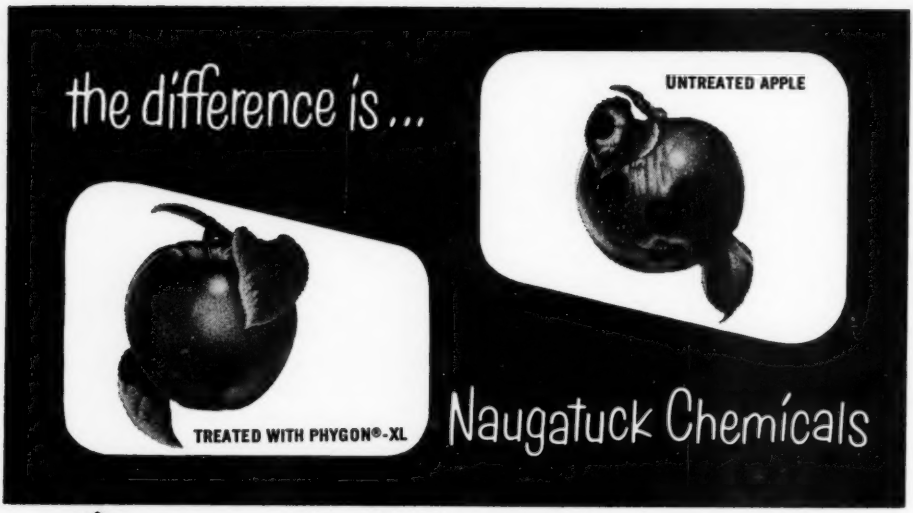

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